REPORT OF THE

FAO TECHNICAL MEETING ON PLANT EXPLORATION AND INTRODUCTION

Held in Rome, Italy
10-20 July 1961

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Meeting Report
No. PL.1961/8

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Rome, Italy September, 1961

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INTRODUCTION

A Technical Meeting on Plant Exploration and Introduction was held at the Headquarters of the Food and Agriculture Organization of the United Nations from 10 to 20 July 1961. It was attended by 58 delegates from 28 countries and by 6 observers from other international organizations.

Dr. J. Vallega, in opening the meeting, welcomed the delegates on behalf of the Director-General of FAO.

Mr. William Hartley, of Australia, acted as Chairman of the meeting, assisted by Dr. E. Åberg, of Sweden, and Professor F.G. Brieger, of Brazil, as Vice-Chairmen, with Mr. A. Marzocca, of Argentina, as alternate for Professor Brieger after his departure.

Dr. R.O. Whyte and Dr. G. Julén, of the Crop Production and Improvement Branch of FAO, acted as Technical Secretaries.

The delegates visited the Centro Appenninico at Terminillo at the invitation of the Italian Government and Professor C. Jucci of the University of Pavia.

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1. SUMMARY OF SCIENTIFIC PRESENTATIONS AND DISCUSSIONS

Work of FAO in support of plant exploration and introduction

It may be said that the Organization's concern with this aspect of crop improvement began in 1947/48 when the Sub-Committee on Plant and Animal Stocks considered the establishment of a world clearing-house for information on germ plasm in general, cooperation in plant exploration, the recording of living collections and the removal of artificial barriers to the interchange of plant stocks. (Document PEI/V/1).

A subsequent intensification of interest in the subject was expressed in a recommendation to the 8th Session of the FAO Conference, November 1955, which led to the convening of an informal meeting in London in July 1956. Specialists attended from Australia (Mr. William Hartley in the Chair), U.S.A., Netherlands, France, Sweden and the United Kingdom. The informal recommendations of this group, which have provided the basis for FAO's work since that time, were given in Chapter 7 of the Agricultural Study No.41. This development of international action received further support from recommendations or resolutions made at a number of international conferences, e.g.:-

7th International Grassland Congress, New Zealand, November 1956.
3rd FAO Regional Conference for Asia and the Far East, Bandung, October 1956.
9th Session of the European Commission on Agriculture, Rome, June 1957.
9th Session of FAO Conference, November 1957.
9th Pacific Science Congress, Bangkok, November 1957.
15th International Horticultural Congress, Nice, April 1958.
10th Session of FAO Conference, November 1959.

Considerable activity has been promoted under the aegis of the FAO Working Parties concerned with rice, maize, wheat and barley, and herbage plants in the Mediterranean Region.

Five living collections of varieties of rice have been established; these are located in India (*indica* types), Japan (*japonica*), Philippines (*indica*), Indonesia (*indica*) and the United States of America (*indica* and *japonica*). In each case, local and introduced varieties are maintained and studied, and seed samples are made available to breeders in other countries.

After the initial introduction of hybrid maize varieties from U.S.A. and Canada into Europe and the Mediterranean region, national collections of local varieties were established in many countries and, in addition, regional collections in Bergamo (Italy), Wageningen (Netherlands), and Belgrade and Zagreb (Yugoslavia), for study, screening, and the provision of seeds to breeders. New hybrids are now available based on inbred lines of local or transatlantic origin.

Collections of wheat varieties, especially those resistant to various types of rust, have been introduced at about 40 centres in the countries of the Eastern Mediterranean and the Near East. Similar collections have been made of barley varieties from many parts of the world. From this work on wheat and barley have now arisen promising varieties for direct multiplication or further breeding work; already in a number of countries several improved varieties have now been distributed to farmers on a large scale.

About 1953, some 25 Uniform Mediterranean Nurseries were established by the member countries of the Working Party for Mediterranean Pasture and Fodder Development. About 250 samples of seed of annual and perennial grasses and legumes were obtained by FAO from the region itself and from other comparable environments throughout the world, and these were distributed to collaborating nurseries for observation according to a standard layout and procedure.

Careful and painstaking work has gone into the collection and dissemination of information relating to the characteristics and availability of genetic stocks of rice, wheat and barley. In order to support FAO's work on the greater use of grain legumes as a source of vegetable protein in human diets, the Organization compiled and published a tabulated list of the named varieties of tropical and subtropical grain legumes. A supplement is now in preparation.

FAO has collaborated in or rendered assistance to plant collecting expeditions. The best example was the joint project between FAO and C.S.I.R.O., Australia, in 1954 to collect pasture species from the natural vegetation in the Mediterranean region for introduction and testing, both in the countries belonging to the FAO Working Party on Mediterranean Pasture and Fodder Development and in Australia. Approximately 600 individual collections made were shared between FAO and C.S.I.R.O. and the FAO share was multiplied at the Research Institute of Prof. de Cillis at Rome. Field observations were made on germination, growth habit and other characters, and seeds were made available for distribution. This collection led, among other things, to the introduction of new material of winter-growing types of *Festuca arundinacea* and other grasses into the United Kingdom.

FAO rendered assistance by arranging for joint collections by Swedish specialists interested in primitive forms of cereals and representatives of the genera *Brassica*, *Sinapis*, *Beta*, *Phleum* and *Dactylis* from Italy, Greece, Turkey and Yugoslavia, together with an Australian collector interested in herbage plants, particularly *Trifolium subterraneum* from isolated habitats in the Aegean Islands. Advice was also given to Professor Yamashita and his colleagues from Kyoto, Japan, who in April-July 1959 visited countries in the eastern Mediterranean and Near East in search of ancestors of wheat; also to Dr. Furusato, of the National Institute of Genetics, Misima, Japan, in the collection of wild species of *Oryza* in parts of Africa.

FAO field officers have also made collections of wild and primitive cultivated forms for use in the countries of their assignment, and for distribution to specialists in other countries. A collection of some 10,000 types of wheat, rye and other Gramineae and Leguminosae was made in Iran, and shared between the Institutes in that country, the Plant Breeding Station at Yesilkoy near Istanbul, the U.S. Department of Agriculture, and the expert's own University in Germany. Collections of herbage plants have been made by the FAO Botanist/Ecologist in the Near East (Plant Introduction Newsletter items 77, 78, 95, 119), for multiplication there and distribution through FAO, and by the FAO Pasture Agronomist in Tunisia (Newsletter items 72 and 113), who has provided further seed samples of the Tunisian ecotypes of *Festuca* and *Dactylis* which are of interest in the United Kingdom.

The Organization has dealt with many enquiries for seeds or vegetative material for use by breeders or for direct multiplication and distribution to growers (see items 101, 140 and 169 in Newsletter). In an attempt to place breeders in direct contact, a special issue of the Newsletter (No.6) was published, giving a list of crop plant collections and their custodians. FAO has also assisted in the assembly of material for inclusion in "germ plasm banks", e.g. the collection of sorghums and other millets for the Rockefeller bank in I.A.R.I., New Delhi.

A list of relevant publications is given at the end of Document PEI/V/1. The main contribution to the interchange of information has been the Plant Introduction Newsletter. It does seem to have filled a gap, the demand for copies has been encouraging and there is evidence that specialists do pick up new information or receive a response to their enquiries published in the Newsletter. When an up-to-date list of plant quarantine services becomes available, this is circulated with the Newsletter for general information.

Current actions and future requirements with regard to specific crops

General.

O.R.S.T.O.M. (L'Office de la Recherche Scientifique et Technique Outre-Mer) is primarily concerned with fundamental research related to the economic development of tropical regions, and is therefore interested in several aspects of plant exploration and introduction (Koechlin, Document PEI/G/1). O.R.S.T.O.M. has a number of research centres in the tropical zones, at Noumea, Tananarive, Brazzaville, Bangui, Fort-Lamy, Yaoundé, Abidjan, Dakar and Cayenne. The activities of O.R.S.T.O.M. proper, with respect to cultivated plants, is somewhat reduced by the existence of a number of specialized Institutes concerned with tropical agronomy, oil crops, and cotton and other fibre crops, for example. O.R.S.T.O.M. would associate itself with all action directed towards the establishment of plant collections, such as that of sorghums and millets being established at New Delhi, India, or the collection of manioc at the station of Lac Alaotra in Madagascar. O.R.S.T.O.M. is ready to collaborate in the formation and maintenance of such collections.

It considers that it is regrettable that there is no international association for workers on the improvement of tropical plants.

The Republic of Senegal, the traditional country of groundnut production, has for some years been attempting to diversify its crop production. New demands arising from independence are at present accelerating this development (Sauger, Document PEI/VI/1). The introduction of a number of crops already made or in progress is directed to this end:

Industrial crops. Groundnut (of which production is planned to increase by 40 per cent in the 4-year Plan), soybean, cotton, Kenaf, castor bean, oil palm, coconut, coffee, tobacco, sesame and safflower.

Food crops. Rice, sorghums, maize, fruits and sugarcane.

Market garden crops. It is planned to increase production by 70 per cent between 1959 and 1964; the principal items are European vegetables, potatoes and Italian tomatoes.

Fodder crops. From many introductions the following have been selected for further study.

Cenchrus ciliaris	Panicum coloratum
C. setigerus	Sorghum halepense
Eragrostis superba	Digitaria umfolozi
Heteropogon contortus	Phaseolus lathyroïdes
Panicum antidotale	Stylosanthes sp.
	Clitoria ternata, etc.

Grain legumes (other than groundnut and soybean). Species of

Phaseolus	Voandzeia
Vigna	Kerstingiella
Dolichos	Cicer

Workers in Senegal require information (through FAO, if possible) to facilitate exchange, e.g. directories of experiment stations, classified by eco-climatic zones, and a summary, for each major crop, of data on geographic distribution, ecological requirements, and lists of main genetic stocks or cultivars with their characteristics.

Cereals

With the assistance of a grant from Rockefeller Foundation, Kyoto University, Japan, organized in April/July, 1959, a Botanical Mission to Eastern Mediterranean countries including U.A.R. (Egypt and Syria), Lebanon, Jordan, Turkey, Greece and Italy. The objective was the collection of wheat and Aegilops for use in the study of the origin of wheat (Yamashita, Document PEI/VIa/1). Dr. H. Kihara had worked out the genealogical relationship of wheats and their relatives. It is thought that common wheat (AABBDD) arose from hybridization between Emmer wheat and Aegilops squarrosa in the Near Eastern Region. Similarly, it is assumed that Emmer wheat originated by crossing between Einkorn

wheat, an existing diploid species, and an unknown species with BB consitution. Recent studies have suggested that the BB-species may be species of the Section Sitopsis of the genus Aegilops. Detailed reports of the subsequent study of the collected material are available.

A collection of indigenous races of maize was started some 25 years ago in São Paulo, Brazil, but a more complete system of collecting was adopted only after a plan had been sponsored by the National Academy of Sciences, Washington, with the participation of the Rockefeller Foundation (Brieger, Document PEI/VIII/1). Three main Centres were set up, in Mexico, Colombia and Brazil, the material collected has been stored for general use, and a complete list was published in Washington. The study of the races collected was also started and a series of publications has come out, copies of which can be obtained from the National Academy of Sciences in Washington or from I.C.A. in Washington.

It has become evident that for maize, as with other American crop plants, the gene-centre theory of Vavilov is hardly valid. There is a considerably greater degree of variability in areas where considerable differences of altitude occur, but the tropical lowlands, over areas wider in longitude and especially in latitude, offer equally or even more valuable and variable breeding material. The four main types of maize seem to correspond to successive stages of cultivation and domestication, and each stage shows a different pattern of geographical distribution.

Though maize occurs over an enormous extension of latitude and altitude, exceptionally large for members of one botanical species, the indigenous plant breeder has succeeded in separating a number of gene complexes which give perfect climatic and local adaptation. Another important conclusion, first observed by Wellhausen in Mexico, consists in the fact that the indigenous plant breeder must have used extensively a special breeding technique, establishing synthetic balanced populations from racial hybrids. The established synthetic hybrid races may be somewhat intermediate between the parent races, or they may maintain a large basic bulk of genes from an old race with a strong infiltration from genes of another race coming from an adjoining geographical region. Before the introduction of modern breeding methods, the European settler accidentally rediscovered the same technique.

General conclusions which can be drawn on the basis of work on maize at the Institute of Genetics at São Paulo, Brazil, are:

(1) The old-established sequence: (a) collecting, (b) exportation from the collecting area to other regions with observation of quarantine requirements and, finally (c) study of the collected and imported material, should be altered whenever possible and the study of the material should be started in the area where collecting has been made or at least near it. This would result in benefits in two directions: the loss of valuable genetical material during and owing

to the exporation-importation procedure could be diminished. Furthermore, it will always be advantageous to stimulate local interest. This will lead eventually to a passing from the former stage when collecting was a kind of exploitation of foreign regions to a new phase where the conservation of valuable material in their original countries will become the most important feature, and when the exploration or exchange of material can be made on a sounder scientific basis, after previous screening without too many climatic changes.

(2) When collecting material of a natural flora, it is of course the custom to collect as many data as possible on climatic and ecological conditions. When collecting cultivated material, information of an agronomic nature should also be collected even if this be given in a primitive form by an uneducated farmer. He will always know not only how he grows his material but also how he conserves its qualities, and an intelligent collector should be able to translate this often rather crude information into scientific modern language resulting in valuable information about the breeding structure of the material.

The Rockefeller Foundation initiated a programme of cereal improvement at the invitation of the Government of India with the establishment of an active programme in maize and millets in January 1957 (Rachie, Document PEI/VIa/2). The programme that developed is similar to the agricultural programmes established earlier in Mexico (1943), Colombia (1950) and Chile (May 1955) except that the Indian Agricultural Programme is directly integrated with Government of India agencies and institutions such as the Indian Council of Agricultural Research and the Indian Agricultural Research Institute at New Delhi.

The RF Cereal Improvement Program in India includes maize and the millets. The maize programme was started earlier and received considerable impetus from the Government of India. The millets programme, which has concentrated its efforts mainly on sorghum and to a lesser extent on pearl millet (Pennisetum typhoides), was to be implemented mainly through the Indian Council of Agricultural Research's Project for Intensification of Regional Research on Cotton, Oilseeds and Millets. This project is now being implemented through the establishment of centres and subcentres located in most Indian States. Several of these programmes though sanctioned have not yet been started. Efforts on sorghum improvement in this project have to date been supported by the Rockefeller Foundation to some extent in cooperation with existing States' programmes.

The objectives of the cooperative efforts on millet improvement are of a practical nature: increased production and better quality of grain and fodder for human and animal consumption. Specific functions of this programme carried out in cooperation with the Government of India, its agencies and the important sorghum growing States are the following:

(1) Procure, maintain and distribute a complete range of the presently available millet germplasm for breeding and testing purposes.

(2) Carry out an intensive and systematic India-wide collection of sorghums, pearl millets, lesser millets and maize. The collections will be retained at Delhi, evaluated at several locations, and made available to breeding programmes.

(3) Organize uniform yield trials of improved varieties and hybrids of sorghum and millets on an India-wide basis.

(4) Develop hybrid sorghums through the use of cytoplasmic male sterility. Promising experimental testcrosses will be grown and tested under a wide range of conditions and then included in the uniform yield trials before releasing to seed-producing agencies.

(5) Conduct basic genetic and other research studies related to millet breeding or improvement problems.

(6) Supply modern equipment, literature and references to selected millet improvement projects, with help for developing maximum efficiency in research and breeding procedures.

(7) Provide for the training of millet specialists in efficient techniques and methods of breeding and testing of varieties.

(8) Facilitate exchange of information by periodic meetings of research workers, publication of reports and progress, and the duplication and wide distribution of important reference sources and scientific articles.

One of the important functions of the programme is to make sorghum and millet germplasm available to breeders throughout India. Most of the millet projects in India have a very limited range of types or varieties and lack facilities for long-term storage. The germplasm includes collections from every important millet producing country, but the most valuable exotic breeding materials have been obtained from Africa and the United States of America. All of these seed stocks are made available to other breeders upon request and it is planned eventually to publish and distribute a list of all varieties being maintained together with their important characteristics. More than 5,890 separate seed lots of sorghum and millets have been distributed, three-quarters of which went to Indian specialists. The systematic collection of millets and maize has not previously been made in India. Therefore the Rockefeller Foundation in collaboration with the Indian Council of Agricultural Research is now making an intensive survey and collection of sorghum, millets and maize in India.

A single field unit collected 116 crop samples during the 1959-60 season and two field units operating in 1960-61 collected 2,215 samples. These are divided as follows:-

Crop	Collection
Sorghums	1,703
Pearlmillets (Pennisetum typhoides)	462
Small millets (*)	814
Maize	352
Total	3,331

(*) Small millets include species of Eleusine, Setaria, Panicum, Echinochloa and others.

Improvement work on the millets has largely been confined to sorghums, although a limited amount of testing has been carried out on the pearl millets (Pennisetum typhoides) and the seeds of other millets are being collected and maintained at I.A.R.I., New Delhi. Increasing the production of sorghums in India represents a formidable challenge to plant improvement specialists; but there is considerable scope for improvement as evidenced by present low average yields. The problems of increasing production are many and inter-related. They involve sociological, economic and environmental factors in addition to those of plant protection and improvement. Insects are by a considerable margin the most important plant protection problem. Diseases are of less importance.

Soil and weather factors are always important considerations. Depleted soils and low fertility are particularly important in limiting yields of sorghum and millets. Most Indian cultivators apply their limited quota of commercial fertilizers on "cash crops" like cotton and sugar-cane, believing that millet crops do not respond or "pay-off" on fertilizer investment as other crops. Varieties and hybdrids are under development that respond better at higher level of fertility. Cooperative tests are being conducted to determine optimum yielding capacities of local strains compared with high-yielding exotic strains and hybrids. Weeds are usually troublesome but seem to be doubly so in India during the warm, humid monsoon season.

A considerable amount of work will be required to achieve some real break-throughs in sorghum improvement in India, but the future now appears brighter and problems do not seem as large or insurmountable as in the past. The excellent adaptation and widespread cultivation of millets; the large number of uses for these important crops,; and the great range of genetic variability that exists and can be brought together in almost any combination, give these crops almost infinite potential to help meet the increasing shortfall of foodgrains in India.

Grain legumes

During recent years, arrangements have been made by the Regional Research Station in Samaru in Northern Nigeria to collect and conserve comprehensive assemblies of the staple food crops, maize, sorghum and millet, and most recently, grain legumes. The last of these surveys anticipated the Grain Legume Project of the FAO Freedom-from-Hunger Campaign by a matter of months (Stanton, Document PEI/VIc/1).

The boundaries of areas of dispersal of a particular cultivar are controlled in part ecologically and in part sociologically. The conservation of a particular cultivar and the direction in which it is being selected are also due to social factors. These features affect the method of collecting samples and the type of data collected with the sample. A standard form was designed and data recorded on punch cards. The survey has yielded some 200 samples of Vigna sinensis, Voandzeia subterranea, Sphenostylis stenocarpa, Phaseolus lunatus, Ph. aureus, Ph. vulgaris, Cajanus cajan, Parkia, Cassia and various wild legumes. A total of 600 samples is ultimately expected. The technique adopted has proved very satisfactory and the data will provide basic information for a wide range of agricultural and sociological projects.

Industrial crops

Although much breeding work has been achieved with coffee, cacao and rubber, much more has to be done, considering their importance to the economy of tropical regions and the need to develop new varieties presenting better characteristics of productivity, quality and resistance to pests and diseases (Krug, Document PEI/VIb/2). The breeding programmes are often handicapped by the insufficient genetic variability of the germ plasm available to the breeder. In the Document, the geographic distribution of the genera Coffea, Theobroma and Hevea is reviewed, the main cultivated species are mentioned with their breeding problems, and the existing collections are indicated. There is an urgent need for further introduction of genetic stocks and it is suggested that such undertakings should be carried out through international cooperation.

Concerning coffee, FAO considers it desirable to organize three collecting expeditions - two to Africa and one to India and south-east Asia - and to establish nine world collections of Coffea - three in the western hemisphere, four in Africa, one in India and one in Indonesia. With cacao, two projects for international collaboration are concerned with exploration for native cacao and the establishment of world collections. As regards rubber, it is proposed to re-establish at the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica, a centre for testing resistance to South American leafblight, Dothidella ulei.

In view of the lack of resistance of commercial south-east Asian varieties of Hevea brasiliensis to South American leafblight, it is important to stress the need for resistant clones for further work in south-east Asia and to discuss the possible value of exchanges between the New World and the Old (Wycherley and Brookson, Document PEI/VIb/3). Alternative methods of exchange of planting material are:

(1) The free exchange and disposal of selections; abolition of proprietary rights.

(2) The continuation of the present system of unilateral agreements, and

(3) Comprehensive multilateral agreements.

The third alternative is by no means new, but the relevant points should be emphasized:

(1) Participation would be voluntary.

(2) Material and services would be recognized.

(3) There would be adaptability to allow multilateral cooperation in more than one crop.

(4) Respect would be given to existing rights and privileges, the incentive value of which would be increased by their mutual observance and the wider cooperation obtainable.

(5) Reimbursement for materials and services would be in kind as far as appropriate.

Theobroma is confined to two regions of the humid tropics in South and Central America, separated by the Andes, namely: (a) the Amazon Valley and the Guianas, and (b) the Pacific slopes of the Andes and Central America (Bartley, Document PEI/VId/1). The cacaos from these two areas are morphologically dissimilar. The document reviews the results obtained from the explorations made by F.J. Pound and other collectors, and by I.C.T.A. in 1952. A large amount of useful genetic variability was discovered which is being utilized in breeding programmes. Most of the Amazon cacao is associated with former human settlements. A collection of the other non-commercial species is maintained at Trinidad (Faculty of Agriculture, University College of West Indies) and studies of interspecific relationships and disease problems are made.

It is realized that there is a need to retain sufficient variability in the population of "Trinitario" cacao. If all the present "Trinitario" seedling-propagated cacao were to be replaced by a few vegetatively propagated, high-yielding clones, valuable variability would be lost, as well as the special flavour of "Trinitario" cocoa, which seems to be due to the mixture of seedlings in the present population. Taxonomic revisions of the genus Theobroma are in progress at the Smithsonian Institution in Washington, D. C., and the Department of Economic Botany of the Peabody Museum, Harvard University.

Workers in Israel presume that the primary centre of Ricinus communis is in East Africa; the species is a tropical perennial (Stein, Document PEI/VIb/1). However, time of flowering varies over a wide range within the species, and some very early, dwarf types complete the seed-to-seed cycle in the short frost-free period of the temperate zone, thus becoming annuals. The common mode of seed dispersal is by explosive opening of the capsule; in the presence of two recessive genes, the capsules fail to open and eventually drop off with the enclosed seeds. Explosive shattering is probably of adaptive value in the tall, perennial types, where proximity of seedlings to the established parent plant would be disadvantageous. On the other hand, seedlings of dwarf, annual types do not suffer from competition of the parent plant, and seeds are better protected during winter in the hull. Thus, natural selection seems to have brought together dwarf stature (early flowering) and indehiscence. This combination of characters has also been sought by breeders since Ricinus became established as an annual, largely mechanised crop, and many modern varieties were developed from subspontaneous plants of the temperate zone. Wild types from the primary centre of origin are of little breeding value. They possess some general pest and disease resistance, correlated with vigorous growth and large plant size. Despite the great antiquity of Ricinus as a cultivated plant, wild types and cultivated varieties are completely interfertile, except one case of incompatibility determined by the interaction of a recessive gene and the cytoplasm. Since the two incompatible lines also represent ecological extremes, this may be the beginning of subdivision of the species.

In the discussion on this section, the Meeting was informed that Dr. F.G. Myer of the United States will soon make an expedition to Ethiopia, and adjacent countries to clarify taxonomic problems in Coffea and to collect germ plasm. It was agreed that it would be desirable for specialists from Kenya and Tanganyika, and perhaps also Brazil, to join this expedition to collect disease-resistant material.

Considerable use is being made of Amazon cacaos at the West African Cocoa Research Institute, Ghana. West African Amelonado (forastero) usually gives 200 kg. per ha. on peasant farms in Ghana; if these yields are 600 kg. per ha., selected Amazon cacao gives 1,000 kg. per ha. Amelonado takes 10 years to come into full bearing, Amazons only 5 to 7 years. Hybrids between Africa and American cacaos give 1,500 to 2,000 kg. per ha. and bear in 3 to 5 years. Amazon seed is being widely distributed in Ghana, Nigeria and Sierra Leone.

With reference to the Malayan suggestion regarding multilateral arrangements for the exchange of Hevea material, it was agreed that such arrangements should also include West African countries, and that the free distribution of breeding material could best be organized through an international agency such as FAO.

A discussion ensued with regard to priorities as between food crops and the major tropical cash crops which were already the concern of large research organizations, well equipped and staffed, and often supported financially by private interests in trade and industry. Food plants, on the other hand, are often neglected or at least do not benefit from this type of support. Some tropical crops such as the coconut palm would, however, justify action on an international cooperative basis. The preliminary FAO catalogue on coconuts could be improved on the basis of recent results; tropical Oceania may well be the area of maximum diversity of this crop and might yield valuable breeding material. It was agreed that a reasonable compromise was desirable as between food and cash crops, since the latter are frequently the means of raising the standards of living and are therefore efficient in reducing hunger and malnutrition.

Horticultural plants

From Theophrastus, Cato the Elder and Pliny the Elder, to the present-day, general writers and specialists have listed species and varieties of fruit plants (Pansiot, Document PEI/VIe/5). Many important recent compilations have appeared, giving national lists of varieties of fruit trees, berry fruits and vines. There is also a World List of Citrus Collections, and it would be very interesting to have similar lists for dates, bananas, mangoes, apples, pears and peaches, etc. FAO is compiling a World List of Living Collections of Fruit, Nut and Beverage Species for publication late in 1961. Replies to a questionnaire have been received from about 500 research stations.

The Station de Recherches d'Arboriculture Fruitière de la Grande Ferrade, Pont-de-la-Maye (Gironde), France, is at present assembling as complete a collection as possible of the species of the genus Prunus (Souty, Document PEI/VIa/4). Because of the difficulties associated with the introduction of seeds, the interest is mainly in grafting material, and the assistance of FAO is requested in this work.

As regards the Western cultivated carrot (Banga, Document PEI/VIe/1), it has so far been generally assumed that the cultivated carrot is the result of a hybridization process, which took place in the Mediterranean area. Evidence is, however, available to show that hybridization did not play an essential part in the genesis of the cultivated carrot, and that there is more reason to believe that mutation followed by selection has been the main factor. The purple anthocyanin carrot probably spread from Afghanistan to part of the Mediterranean area in the tenth, eleventh and twelfth centuries, and to Western Europe in the fourteenth and fifteenth centuries. It reached China at the end of the thirteenth or in the fourteenth century, and Japan in the seventeenth century. A yellow colour variant of the anthocyanin carrot spread at the same time. The white and the orange carrot are probably mutations of the yellow carrot. The first orange types of cultivated carrot were selected in the Netherlands in the seventeenth century. It is thought that these are all the same species, as they have the same chromosome numbers. The purple type is probably the oldest form.

Ornamentals, like food crops, have a certain economic value (Boom, Document PEI/VIe/2). Important breeding work has now started on a scientific basis and it has become necessary to introduce wild material to enrich the germ plasm. One has to allow for variations because of changing public tastes. Work may be divided into three parts - the initial introduction itself, the care of the introduced material and the subsequent breeding work. The second objective is the most important because it is useless to introduce plants if they cannot be maintained. Centres which might be appropriate for maintaining germ plasm of ornamentals are botanic gardens, plant introduction gardens and research stations. Botanic gardens and introduction gardens are generally not really suitable, as the variation within ornamental species is too large, the methods of cultivation vary too widely and identification is too complex. Therefore, only institutes with a special interest can be considered; for example, arboreta and research stations. It would appear that decentralization would ensure the most efficient work. Introduction has to be followed by breeding or distribution of material to the nurseries. It should be recommended that research stations employ plant collectors, who should be botanists with sufficient floristic knowledge and a horticultural flair in looking for the right species. In special cases the man in charge has to do this work himself. It is desirable that a committee be established at the present opportune time to co-ordinate the decentralized work and to compile a list of germ plasm banks.

Herbage and fodder plants

The distribution of some of the cosmopolitan subfamilies and tribes of the grasses, when mapped on the basis of their percentage frequency in the grass flora, shows a close relationship to climatic factors (Hartley, Document PEI/VIf/4). Hence comparisons of the tribal composition of the grass flora provide a useful method of comparing the environments of geographically separated regions.

Investigations are in progress to determine the possibility of establishing better types of pasture plants in the arid region of Central Australia, where the native species are not of high grazing value. Three large taxa of grasses - the subfamily Eragrostoideae and the tribes Paniceae and Andropogoneae - together make up most of the grass flora of this region, and the floristic comparisons discussed in this paper are based on them.

The composition of the grass flora of Central Australia has been compared diagrammatically with that of various regions in the arid zones of Asia, Africa and America. The grass flora of Central Australia is almost identical in tribal composition with that of the Yemen region of Arabia and that of Western Somalia. There are close similarities also to the grass flora of other arid regions in Africa, to parts of Pakistan and Western India, and to the arid regions of Northern Mexico. It is concluded that these regions are the best potential sources of new pasture plants for trial in Central Australia.

As a test of the validity of this conclusion, the distribution of Buffel grass (Cenchrus ciliaris L.) has been studied. Buffel grass is the only exotic pasture species of approved value which has become established and naturalized in Central Australia. There is a very close coincidence between the area of natural distribution of Buffel grass in Africa and Asia and those regions which have a grass flora similar in tribal composition to that of Central Australia. It appears, therefore, that comparisons of grass flora, used in conjunction with other methods for the comparison of plant environment on an international scale, can provide a sound basis for pasture plant introduction and exploration.

Improved varieties of herbage plants must possess a complex of superior agronomic, physiological, nutritional and reproductive characters (Thomas, Document PEI/VIf/1). Associated with this is the importance of close adaptation of these varieties to the climatic and other conditions where they will be grown. For Great Britain, winter hardiness, winter production and growth rhythm in relation to flowering are important characteristics, since the country is situated more or less between the winter-dormant areas of northern Europe and the summer-dormant conditions of the Mediterranean. Thanks to active collaboration with FAO and others, the Welsh Plant Breeding Station at Aberystwyth has been able to develop potential varieties which possess increased winter growth without excessive summer dormancy. The characteristics and breeding potential of an extensive collection of Dactylis material have been studied.

There is an enormous genetic variation for time of flowering and other physiological characters even within a single adapted variety but there appears to be some limit to the exploitation of this variation by selection. Intense selection for the extreme expression of any one character may lead to unfavourable correlated responses in other characters such as fertility. For this reason it is necessary to incorporate new variation from otherwise unadapted material obtained by collection over a

wider geographical area. This work emphasizes the value of close collaboration between plant collectors, geneticists and climatologists which should ultimately lead to the development of improved varieties better adapted to the different regions of the world.

In 1956, a Swedish expedition collected in the Mediterranean region (Ellerström, Document PEI/VIf/2). In cereals, genes for qualitative characters may be obtained from exotic material even if this material is not well adapted to Swedish growing conditions. An improvement of quantitative characters by the aid of exotic material, on the other hand, is practically possible only if the exotic material in question is rather well adapted to Swedish conditions. Otherwise extensive breeding work over a long period of time is necessary in order to "reconstruct" the well-balanced genetic system of the native varieties.

Breeding has on the whole been more successful with autogamous than with allogamous crops. Thus the differences between the high-bred varieties and the primitive forms are in many cases less pronounced among allogamous crops. Consequently, exotic material may be used more successfully in breeding such crops. A combination of introduction of exotic material to widen the genetic variation of native breeding material, and autopolyploidy might be rather promising as a method of improving allogamous crops, at least as far as production of vegetative parts is concerned.

To some extent, it is true that there have been few examples of promising introductions of wild species. At least among cruciferous and leguminous plants as well as among grasses, samples of wild species have been selected because of their potential practical value. Naturally, rather extensive breeding has to be carried out to adapt such material to Swedish conditions and to improve agronomic characters. However, it has been impossible to add such an extensive breeding task to the ordinary programme without enlargement of staff and facilities. Special institutes, not directly concerned with the practical value of their work, will have to test wild material and do the initial breeding work to bring the material to a stage where a decision could be made with regard to its practical possibilities.

Such an institute should not only concentrate on the testing of potential new crops but should take care of the collecting, testing and maintenance of potentially valuable plant material, in the same way as institutes in Australia, USSR and the United States. It is hoped that it will be possible through international co-operation to establish such institutes with enough facilities to save the invaluable genetic sources present in primitive forms and wild species and to supply plant breeders with such material, thus increasing their possibilities of improving the world's food supplies.

The eastern part of the Mediterranean basin and the adjacent countries of Anterior Asia are extremely rich in species of _Trifolium_ (Oppenheimer, Document PEI/VIf/3). Israel has about 40 species which form a major component of its natural pastures. None of these has so far reached the stage of cultivation. Most wild species include ecotypes which may be of interest to countries with a similar climate

and soil. Some workers have found the highly competitive and very polymorphous T. purpureum Lois. (or rather its oriental variety T. roussaeanum) useful because of its high productivity and long growing season. The wild T. alexandrinum L. (T. berythaeum Boiss. et Blanche, and possibly other insufficiently studied varieties) is worthy of attention for breeding for heavy soils often flooded in winter. The closely related T. carmeli Boiss., preferring maquis associations on Mt. Carmel and Galilee, was recommended by Aaronsohn to David Fairchild as long ago as 1907 for introduction into the U.S.A., but seems to have remained unnoticed ever since. A new variety of T. scutatum Boiss. which we have called var. erinaceum (Bull. Soc. bot. France, 108, 1961), is widespread around Jerusalem and elsewhere. T. subterraneum L. from Israel has aroused interest among Australian breeders. The closely related T. israeliticum D. Zohary and Katznelson, recently described as an independent species, seems promising, in particular because of its earlier development and resistance to drought and limestone, in comparison with T. subterraneum.

Observations on local T. neglectum, incorrectly designated as T. fragiferum L., revealed types more leafy and productive than the early strain known as "Palestine Strawberry Clover". In the same section of the genus, Galearia, we find many species, varieties and forms closely related to T. resupinatum. Of these, var. maior Boiss. of the latter, doubtfully separated from the Persian Clover or chabdar (T. suaveolens Willd.), is a vigorous grower in wet habitats, while T. clusii Boiss. is widespread in the Mediterranean hills. A species which has impressed is T. spumosum L., although sowings in pastures have not been encouraging. The related T. xerocephalum Fenzl, though a poor producer in drier environments and on poor or shallow soil, might be interesting for eroded and dry localities. In marked contrast, a vigorous and productive local variety of the white clover (T. repens L.), probably identical botanically with Ladino clover and included in var. giganteum Lagrèze-Fossat, thrives only under wet conditions. It is being tried as a cultivated pasture crop. The related annual T. petrisavii Clem. of creeping and expansive growth habit appears promising on heavy and wet soils.

In the discussion on the use of floristic studies, it was suggested that the method could now be adopted widely, as the flora of the zone does not depend only on the present ecology, but is the result of the long history of climate and geology in the region. The similarities observed may well be a coincidence. It was agreed that it would be better not to base a method on a single control plant, Cenchrus ciliaris, but to use more species and to conduct the work on an international scale. Climatic similarities between different places of introduction or of diffusion of varieties must be closer for annual plants, but the method proposed considers essentially perennial plants. The climatographic method is, of course, of universal value and cannot be substituted by the floristic method. The latter does, however, provide useful data under certain conditions.

The question was raised of the relation of sterility in plants selected at Aberystwyth for earliness or lateness with the cytological processes. This phenomenon depends on the balance of genes in the

chromosomes and the sterility occurs at the 5th or 6th generation. At Versailles, southern ecotypes have also been studied; they are not usually very cold-resistant, and the Tunisian Festuca arundinacea has too narrow leaves.

The choice of the region of collection by the Swedish specialists was determined by a particular interest in Brassica oleracea, Hordeum bulbosum and other species. From the point of view of winter hardiness, valuable material is more likely to be found in eastern Anatolia than in the coastal regions of the western Mediterranean. In any case, valuable samples of various crops have been found in spite of the fact that the climatic conditions in the Mediterranean region are rather different from those prevailing in Sweden. The trial of durum wheat in Sweden has shown that there are possibilities in breeding durum varieties sufficiently well-adapted to give a good yield and fairly high quality for the production of macaroni.

The genecological basis of exploration and collection

In pasture plant introduction it is important to consider phyto-geographical factors (Hartley, Document PEI/VII/1). For successful introduction of new pasture plants into regions at present used for "natural" grazing, it is essential that the plants introduced should be closely adapted to the environment in which they are to be grown. They must therefore be sought in regions which are closely comparable in climate and other environmental factors. The methods available for broad environmental comparison on an international scale can be reviewed under the heads of climatic comparisons, vegetation comparisons, floristic comparisons, and crop index comparisons. The broad climatic indices and maps such as those developed by Köppen and Thornthwaite provide a useful basis, but the boundaries between climatic types must be reassessed in the light of data on plant distribution rather than vegetation distribution. Vegetation comparisons are of limited value for plant introduction, as there are no satisfactory criteria for vegetation mapping on an international scale. Composite maps, utilizing both climatic and vegetational data, may be useful.

Floristic methods of environmental comparison are preferable to vegetation comparisons, as the flora of any region is less subject to artificial disturbance than is the vegetation. They are, however, difficult to apply in practice, as most taxa have a very restricted distribution. Raunkiaer's life-form spectra provide a method of environmental comparison on a floristic basis, while the "agrostological index" has special applicability to pasture plant introduction.

The agro-climatic studies of Nuttonson are the most comprehensive and successful approach to the comparison of environments on a crop index basis. They are useful rather in the international exchange of established cultivars than in the introduction and testing of wild ecotypes.

In the study of the origin, classification and ecology of herbage and fodder plants, it is noted that there exists a grass/animal complex that explains the relationship between the composition of vegetation and

grazing animals (Hédin, Document PEI/VII/5). Therefore, generally we find plants used for animal feeding in the regions where important herds of wild animals grazed before the beginning of agriculture. Often we find the most interesting plants in the regions where the climate is uniform during all the year. In these regions there are hygrophyllous species while in the steppes there are plants with narrow and sometimes prickly leaves. In mountainous regions, forage species are interesting because wild goats and sheep lived there formerly. In the beginning of agriculture, people sowed usually the wastes of cereals consumed by Man to feed animals (Farrage). Grazing was usual in the forests so that many regions have lost a great part of their forests. The recent domestication of forage plants (except lucerne) began in the west of Europe, in the beginning of the agricultural revolution which took place at the same time as economic and social transformations from the first part of the 16th century. The stages of this domestication became more and more rational, and a classification of forage plants may be based upon the history of this domestication. Many forage crops were formerly cultivated as food for Man and many weeds became forage plants.

As to the ecological characteristics of forage species, there are hygrophyllous plants and nitrophyllous plants, and many are sciaphyllous. One finds annual early species in dry regions, where they are able to grow during the short rainy season. There is a need for teaching courses to study the problem of adaptation of plants to their environment.

There is a correspondence between ecological - chiefly climatic - conditions and genetic constitution of populations; hence a possibility of selecting from these populations factors of fitness and resistance to difficult environments; characteristics and difficulties are easy to register in a meteorological and agrological study of an area (Jucci, Document PEI/VII/2). Adaptation and fitness are elastic in nature: in local populations several different biotypes co-exist which are successful in the environment since the relative weakness of one factor is compensated by efficiency of another; resistance to a semi-alpine environment could be gained through specific frost-resistance or through a degree of earliness. Experimentation is likely to reveal this individual variability of genetic constitution by cloning individual plants and transplanting these to different environments, in transplant Stations like those of the Carnegie Institution in Sierra Nevada, or of the Appennine Centre on Monte Terminillo.

After the isolation of different biotypes in a local population - and of different ecological races in an ecospecies (sensu Turesson) - inter-crossing of biotypes and races could release the potentialities often concealed in a hypostatic form, and could indicate the nature of genic material at one's disposal. To make a rational and efficient collection, it is necessary to consider not only the climatic conditions, but also the morphological characteristics correlated with physiological adaptation to the environment itself; this could indicate the mechanism of such adaptation. For instance, with ecotypes of drought-resistant potatoes, it would be better to discard the types that acquire this resistance through the extreme reduction of leaves and choose others that have normal leaves but survive the critical period because of the water accumulated in their tubers. In order to be able to select suitable

ecotypes it is necessary to consider carefully the floristic association characteristic of the area. Such phytosociological criteria may help to define better not only the adaptation to climatic factors, but also the edaphic factors of the environment.

Although the value of comparative climatic studies for plant exploration and introduction is not yet generally accepted, consideration should be given to the potential contribution of such studies for the different situations with which research workers have to deal (Perrin de Brichambaut, Document PEI/VII/7). It must in the first place be emphasized that in underdeveloped countries and remote areas, microclimatology cannot be taken as a basis for plant introduction, and that only regional climatology permits comparisons which may be useful in some instances.

1) The plant explorer who collects wild species and primitive cultivated forms generally goes to primary and secondary centres which are often located in areas with a highly dissected topography and a remarkable variety of ecological conditions determined by microrelief, exposure, soils, etc. In this mosaic of contrasting environments, as well as in stands of primitive cultivated forms, microclimatic studies are neither possible nor useful. However, it is always desirable to have information on the regional climate which determines a number of biological characters in the forms which are found.

2) When landraces composed of many related forms are to be introduced, general information on the climate of the region in which they are grown should suffice, since these varieties are generally adapted to a fairly wide range of conditions.

3) Climatic comparisons appear very promising for introductions of improved cultivars and of ecotypes and should make it possible to avoid certain mistakes. A good knowledge of the climate of the site and the region where a variety is to be found and a study of the response of this variety to certain climatic extremes should provide an indication of the areas in which it may be climatically adaptable. These studies of climatic homologues can, of course, never replace systematic experiments in the introduction nurseries located in the different climatic zones of the importing country.

4) The introduction of highly bred cultivars cannot be based exclusively on the comparability of regional climates. Only microclimatic studies combined with pedological and agronomic data can indicate the areas of adaptation of these highly bred cultivars.

The general climatic classifications now in use do not make it possible to delimit the regions to which a plant is climatically adapted. For the exchange of plant material it is therefore necessary to study all climatic factors in relation to growth season and climatic thresholds of plants, extreme values, and so on. Once the macroclimate of the research stations and experimental fields and its relations to

the phenological cycle of the introduced species have been studied carefully, it would be useful to disseminate this information and to search for climatic homologues within a given geographical region. The more progress is made in climatology, the more useful climatic comparisons will become for the purposes of plant introduction.

It should be realized that not all cultivated plants have necessarily arisen in the eight independent centres of origin recognized by Vavilov. (Purseglove, Document PEI/VII/4). Furthermore, some crops may have died out of the areas where they formerly flourished, and have found secondary centres of diversity in favourable areas where conditions for evolution are different. The generalization that the centre of origin of a taxon is the area in which the more advanced species are found should also be treated with caution. New cultivars are evolved at the periphery of migration or when encountering unfavourable conditions. Plants rarely occupy anything like the whole of the geographical range in which climate and soils are suitable. Although the Vavilov dispersal centres may show the greatest qualitative variability, they are not necessarily the centres of the maximum expression of a character in a new direction.

The extent of movement of crop plants within the Old World before the time of European exploration is not always realized. Crops from Inner Asia had reached India and Central Europe before 3,000 B.C. Crops which originated in Africa had reached Asia and China at an early date. The routes of some of these dispersals can be traced, with specific reference to a number of important tropical crops - e.g. the gourd (Lagenaria siceraria), sweet potato, coconut and cotton. The areas of maximum production for export of many economic tropical crops are far removed from their sources of origin.

One of the most important factors in the establishment of a new food crop in an area is that there must be a place for that crop in the agricultural system and some kind of guarantee that it will produce a large quantity of food for less labour or cost than the crops which are already being grown, e.g. maize throughout the world, sweet potato, species of Phaseolus, soybean, etc.

The origin and distribution of tropical weeds follows closely the pattern observed in tropical crops and among the most troublesome weeds are those which have been introduced adventitiously into new areas without taking their specific pests and diseases along with them.

The Potato Gene Centre in South America is of great importance for the breeding and understanding of the origin of the cultivated potato (Ross, Document PEI/VII/6). Solanum Section Tuberarium has two centres of diversity: the Andes of Bolivia and Peru and the mountain region of Mexico. Within these boundaries the cultivated forms have their centre in the high Andean region above 2,000 m. between Potosi in Bolivia and Huaraz in Peru. Valuable properties within present-day potatoes are only few beyond short stolons, yield and taste: hypersensitivity to the viruses A and X and resistance to the common race

of Synchytrium endobioticum. The gene centre has contributed the following properties from primitive cultivars: high starch and deep yellow flesh in tuber, resistance to frost, immunity to virus X, resistance to leaf-roll virus, resistance to several races of Synchytrium endobioticum, field resistance to Phytophthora infestans and resistance to the common race of Heterodera rostochiensis. Studying the wild species of the gene centre the following characters are found: resistance to darkening of the tuber flesh, immunity to the viruses A and Y (Solanum stoloniferum, S. chacoense), higher resistance to the leaf-roll virus (S. demissum, S. acaule), higher resistance to Phytophthora infestans (S. demissum, S. stoloniferum), resistance to Leptinotarsa decemlineata and Epilachna (S. chacoense) and resistance so far to all races of Heterodera rostochiensis (S. famatinae and S. vernei).

One cannot but say that the use of gene sources of wild species and primitive forms is very advanced in potato breeding. But there remains an urgent need for earliness in ripening, immunity to leaf-roll virus, higher resistance to Phytophthora infestans, resistance to Erwinia phytophthora, Rhizoctonia solani and Streptomyces scabies. Moreover, potato breeding is also faced with the breakdown of resistance due to the variability of the parasites.

Since 1954, eight Solanum collecting expeditions have been made in Mexico, Central and South America. New forms and species have been found, and the gene centre has by no means been exhaustively investigated. The screening of wild species has shown that an especially valuable character such as virus immunity or frost resistance is not one common to a species as a whole but is restricted to some strains or varieties of that species. The screening for a special property in potato wild material therefore would have to be done with, say, 20 varieties of each of nearly 150 Solanum species. This is an impossible task.

Studies within the gene centre offer a solution of this problem. Generally speaking, hosts and their parasites have the same gene centre, where they have developed their greatest diversity mechanisms for attack and defence. But the gene centre covers a wide range of different geographic regions, and parasites and species differ in their needs for special biotopes. So resistance to a special parasite is to be expected only in those Solanum species living in climatically defined habitats to which that parasite is best adapted. A planned exploration for properties of resistance to a specific parasite can therefore be performed on a restricted number of wild species. This was one of the tasks of the German Botanical and Agricultural Expedition to the Andes in 1959.

There may be examples of a cultivated plant originating far from the gene centre of its wild relatives, but the first cultivation of the potato began in the very midst of its gene centre. Potato cultivation centres have, since the beginning of cultivation, been in the high Andes

above 2,000 m. The natural vegetation here as with nearly all plant societies is an open one and Solanum species closely related to cultivated ones form an essential part. These related forms belong mainly to the mesophilic Sierra zone (e.g. S. sparsipilum 2n = 24, S. sucrense 2n = 48, and others). When Man colonized these regions and created artificially disturbed habitats similar to the natural ones, the wild Solanum species could easily migrate to the neighbourhood of Man, presenting themselves for use. Today these natural open habitats are seldom wholly without human influence. But we could study some of them with natural vegetation including Solanum species closely related to the cultivated forms. In the open artificial habitats the same species occur and, in addition, there are types which form a transition between non-cultivated and cultivated forms. The genomes of the Solanum species grouped around S. tuberosum are cytogenetically nearly homologous and fertile hybrids are often found in nature. It is, therefore, not surprising that characters of wild forms (e.g. low leaf area) are observed among the cultivated forms and vice versa (e.g. short stolons), this deriving from introgression. Even a far related species, S. acaule, has taken part in introgression, although in a complex manner. This wild species and its cultivated hybrid species with S. tuberosum (S. juzepozukii 2n = 36, S. ajanhuiri 2n = 24, S. curtilobum 2n = 60) have a special selective advantage for Man because of their frost resistance.

In considering the ecological relationships of wild emmer wheat in Israel, it must be stated that the original idea of Aaronsohn, recently stressed again by Schiemann, that wild wheat is a pronounced zerophyte was too far reaching and must be moderated. Recent observations on wild emmer have led to the conclusion that it grows not only in very rocky places, but also on fertile and rather deep soils (Oppenheimer PEI/VII/3). Its area of distribution demonstrates that it is a component of marginal Mediterranean plant associations which is unable to penetrate far into the Irano-Turanian (steppic) territory. Far from germinating only from extremely shallow soil, it emerges easily from several centimetres' depth. It is concluded that ecologically the requirements of wild and cultivated wheat are rather similar. In respect to the theory of the origin of cultivated wheat, Aaronsohn's lasting contributions are, among others: (1) he established the classical view of De Candolle and Koernicke that wheat originated in Anterior Asia, on ample evidence by his field observations on wild wheat, and (2) he first pronounced the idea that primitive man started the cultivation of wheat and barley simultaneously - a fact corroborated again and again in our day by archaeologists.

In the discussion, a warning was given as to the danger of putting too much trust in the system proposed by Hartley (Document PEI/VII/1) to such an extent as to belittle ecological studies. The ecological problems to be faced are the basis of plant introduction, and it is desirable to establish courses in ecology and mapping which would be of particular value to those concerned with plant introduction and the interchange of plant material. Our desire for immediate results should

not detract from the importance of ecological methods. On the other hand, there is a tenden y for such work to become more intensive and to deal with smaller and smaller regions, with little practical value for plant introduction. The climatic factor is not necessarily the only one - the influence of management must also be considered, particularly with herbage plants.

There is a tendency to over-emphasize wild material and to underestimate the significance of cultivars and land races as potential gene pools. The work of collection and study of wild species should run parallel with the study and description of cultivars, according to the provisions of the International Code of Nomenclature for Cultivated plants. It might be possible to arrange that the Registration Centres being established in various countries to deal with cultivars should also provide personnel for studying wild species and primitive forms.

In considering plant introduction it may be necessary to differentiate between the old continents and the new. In old continents it is very rare that new introductions from other areas will be successful, but the situation is quite different with new continents. For the old continents there are a relatively small number of good herbage species, and their genecology needs to be studied carefully. Yet it is a remarkable fact that both Phalaris tuberosa and Trifolium subterraneum have been remarkably successful in Australia; they would probably not have been introduced on the basis of existing ecological knowledge, but they would have been considered on the basis of climatic comparisons. Another species little used in its native habitat (Digitaria decumbens) is now the only grass planted in the West Indies.

In the establishment of stands of annual species, e.g. pasture plants, the dormancy requirements of seeds should be considered; two categories can be recognized, that controlled by genes or natural dormancy, and that conditioned by environment or forced dormancy. Seeds of Aegilops do not have any inherent dormancy, but they are forced to be dormant in their arid habitats.

Polyploid or amphidiploid species are distributed more widely than diploid species, e.g. the hexaploid species, Aegilops triaristata, is found in the whole Mediterranean coastal region, whereas its diploid ancestors, Ae. umbellulata, Ae. comosa and Ae. uniaristata have a limited distribution.

In considering the genecological basis of exploration, one should direct attention to the selection of mutants which are free of alkaloids, glucosides and other toxic principles. This is particularly important in areas in which the natural flora is poor, especially in species of fodder plants or crops for human consumption. Millions of plants may have to be examined to find the mutant types.

The need for standard procedures in the distribution, layout and

recording of plant trials was expressed in relation to autecological studies, but it was felt that this would be difficult to obtain. Often the objective determines the technique. Uniformity is sometimes more apparent than real, especially when factors of season and climate are superimposed. The material tested is not always uniform, e.g. in cross-fertile plants, the populations under observation at different centres may not be the same because of differential survival.

There are examples in Sweden of the importance of microclimatological studies. Within two types of oil crops in the genus Brassica are different growth forms; one has its growing point on the soil surface and the other 2 to 3 cm. above the surface - a difference of importance in varietal winterhardiness. The ability of winter wheat to over-winter depends upon cold resistance, but attacks by parasites may be even more important - these attacks again are closely related to the microclimate.

The success and efficiency of introductions would be greatly increased by climatic and related data, on photoperiodism, the soil, the phytopathological environment, with relation to the place of selection and to the zones of maximum success of the varieties. In Belgium, varieties of wheat have been tested over a range of soil and climatic conditions, but at all centres, although the yields of the varieties differ, they nevertheless always appear in the same order.

There was general agreement that there is a need to reconsiedr the question of the origin of cultivated, and particularly tropical crops. For example, it is doubtful whether Vavilov's centres of origin are always to be found in the present centres of variability - Ethiopia (wheats and barley) and the Himalayas (hexaploid wheats) are, according to Schiemann, accumulation centres. Nevertheless, these areas are of inestimable value to the plant breeder, and should be preserved by international action. With regard to wild Gossypium, present evidence shows that G. barbadense could have arrived as a wild plant in pre-human times and could have been cultivated quite independently in the New World.

Experience in Ghana indicates that a study of local languages by local people can be important in the interpretation of crop names. Routes of introduction of crops are not always reliable because mutation sometimes occurs in an environment of optimal suitability for growth. It must be considered whether there are now also areas that offer the best conditions for greatest mutability.

Conservation of wild species and primitive forms

Collectors of wild species in centres of greatest diversity, particularly in regions with intensive pressure of human and livestock populations, are well aware of the fact that the natural vegetation has suffered from excessive use for thousands of years. This is probably especially true of the Near Eastern region and would obviously affect the efficiency and profitability of collecting expeditions made from the proposed Station in Izmir. There is an urgent need for

the establishment of protected areas of natural vegetation in genetically strategic sites. These areas could be associated with areas protected for ecological studies of progression following removal of biotic factors, but they would have to be managed in a special way to prevent desirable species from being eliminated through recession.

There is also an urgent need to conserve primitive cultivated forms and local varieties or agro-ecotypes in regions of greatest diversity. All cultivated plants have developed from wild species, although in some cases the wild ancestors may have disappeared. Some crops only recently taken into cultivation, e.g. many grasses and legumes, are still very similar to the wild forms. Others cultivated for thousands of years do not greatly resemble their primitive ancestors.

Old cultivated crops have developed a great number of agro-ecotypes or local varieties. These are well-adapted to local conditions, but are often restricted in their area of cultivation. They are well fitted to primitive agriculture but often do not respond well to improved conditions of cultivation. The number of local varieties is often very large.

Local varieties have been and are being used as a basis for breeding. With development of agriculture, the improved varieties become rapidly disseminated and the old local varieties disappear. The genetical basis of the improved varieties is often very narrow, e.g. wheat in Australia and Sweden, maize in the U.S.A., *Digitaria decumbens* in the West Indies and Central America. What will happen as improvement progresses with rice in southeast Asia and the Far East, sorghums and millets in Africa, and wheat and barley in the Near East?

Admittedly, large and important collections have been established, e.g. world collections of wheat (16,000 varieties) and other crops in the U.S.A., Rockefeller Foundation collections of maize in Latin America, and of sorghums and millets in India, collections of coffee, cacao and rubber, rice in the Far East, and so forth.

But we must ask whether the action taken to date is in any way sufficient. What should and can be done further to save valuable gene resources, to assemble and maintain collections, to study them and make the material available to breeders everywhere?

In the Andean area or in the regions of Central America, diversification and variability are rather high in relatively restricted areas; a considerable amount of diversification is also to be found in the lowland areas. In the former, the differences of altitude cause a very wide range of ecological conditions and thus of diversifying adaptation, but the same can occur in the lowlands, if we take much larger extensions of areas into consideration. With the partial exception of the Andean area of Bolivia and Peru, there is

no evidence of any distinct collective centre of domestication, and the tropical crops probably had quite separate centres of origin, but are all now quite widely distributed. The Andean races of maize may have some special breeding value, if anybody would require adaptation to the special conditions of arid areas in high altitude, except the famous Cuzco Large Grain, with its very large kernels and high productivity. The majority of races of some breeding value occur in the lowlands or at intermediate altitudes. Among popcorn races, the Guarani races of southern Brazil, Paraguay and the Bolivian lowlands offer the best breeding material, containing the interesting super-gametophyte factors which impede any contamination with material not containing the super-gametophyte gene. Rather unexpectedly a special type of maize was found over a wide area of the western and southern margins of the Amazon Basin, not only well adapted to extreme tropical conditions, but containing a number of special genes, as a result of a peculiar trend of breeding by the Indians, increasing ear length and interlocking of kernel rows, resulting in an increase of ear row numbers and giving an increase of length and not width of the ear. Though it was believed that *Phaseolus lunatus* has the highest degree of diversification in Guatemala, samples from Indians in the Amazon Basin showed at least as much diversification, including the presence of races with very small and brown beans, i.e. a rather primitive form. In the case of manihot, the highest concentration of wild species seems to occur in central Brazil; a few wild species with fibrous roots have been studied without finding any real advantages. The indigenous material grown by the Indians of the tropical areas is extremely variable, which is easily understood if one remembers that manihot occasionally gives seeds which are scattered, germinate and generally differ from their parent clonal variety, owing to segregation in the highly heterozygous material. Once established, any segregate can be maintained as a new clone and thus as a new 'variety'. The western lowlands and the Andean slopes seem to offer a very high degree of variability of *Arachis*. In pineapple, however, which occurs from the Amazon Basin down to the State of São Paulo, for some reason the most suitable material can be found in and near the Guianas, though no reason can be given why there the Indian plant breeder has selected and maintained a type which satisfies also present day requirements. These citations show that it is difficult in the American tropical lowlands to indicate *a priori* where one should collect plants useful for conservation and exploration as basic breeding material, except of course in the case of long specially adapted material as the potato and other crops originally restricted to very high altitudes in the tropics.

Where plants still exist or even exist mainly as wild plants, as is the case for rubber, the best way would not be the collection, but rather the conservation of special areas as natural reserves. This would still be possible to-day, since most of the areas in question are not yet densely populated and even government-owned land could be found and set aside as a Reservation. But the opening up of these areas progresses very rapidly, with modern means of road

building and the establishment of air strips, and the population on the whole is increasing rapidly. In collecting material one should get as many small samples as possible from different localities; it is less interesting, from the genetical point of view, to collect large quantities of material from restricted areas only. As far as material grown by Indians or by more or less primitive farmers is concerned, their collection is urgently required because they tend to disappear very rapidly. Standard varieties will always tend to penetrate into any newly opened area, not because of their productivity, which even may be low under new and not too suitable conditions, but because they satisfy market requirements.

There remains the serious problem of the maintenance and conservation of the material after it has been collected. Procedures to store the original material so that loss of germination capacity remains at a minimum are very important and the maintenance of a reasonable degree of germination after ten years of storage means that the problem will come up again in ten years. Already a number of collections have been lost; the institute at Piracicaba is participating in the collection and conservation of indigenous races of maize, started under a project by the Academy of Sciences, National Research Council, Washington, and maintained principally by the Rockefeller Foundation, with centres in Mexico, Bogotá and at Piracicaba. In order to reduce the loss of genes to a minimum, a reasonable number of plants must be grown; it will be advisable to collect seeds from all and in about the same amount for each individual, instead of bulking all seeds produced, which would give selective advantage to the plants which for some reason do better than others under experimental conditions. In autogamous plants, seeds from many plants grown from original seeds will be necessary, since natural populations then represent a mixture of many possibly differing lines. In allogamous species, any selfing should be avoided and the maximum of interbreeding within the original sample obtained with as complete a protection against contamination as feasible. This requires either a fairly large number of isolating plots or bagging and hand pollinations. But unfortunately the geneticist must admit that a complete preservation without change of any collected sample is not possible. Restriction of numbers of individuals will always cause a certain amount of inbreeding and the consequent loss of genes, and mutations may occur giving new variants, with an automatic advantage of any gene favourable under the special conditions of the experimental plot used incidentally. It is for this reason that studies of the properties of the collected material should be started as early as possible, in what one hopes to be the future Exploration Centres, to reduce the inevitable accidental loss of material by the elimination of less interesting ones and thus also reducing the number of collections to be maintained by controlled and intentional selection and elimination. No one can ever hope to collect and preserve every variation or wild form of all crop plants, and should restrict his activities to the limits of existing possibilities.

The problem of the conservation of natural vegetation is particularly acute in certain regions in Africa and Madagascar; through deforestation, grazing or burning the natural vegetation it has become seriously modified and impoverished so that the pastoral and agricultural potentialities are markedly reduced. The local types of vegetation, often rich in endemic species, are replaced by a ruderal or secondary flora of little interest. ORSTOM is doing all it can to promote the protection of representative areas of forest and other vegetation in Madagascar and the Congo, for example. Isolated islands with a high degree of endemism should be surveyed with a view to conserving valuable endemic species of potential use in the future. The British Colonial Office is sending a botanist from Kew to the Seychelles to collect there and to suggest areas for the conservation of endemics. The Coco-de-Mer (*Lodoicea sechellarum*) is already preserved.

Over-grazing and mismanagement of livestock in Argentina have led to deterioration of the pasture flora, to the increasing alarm of the producers. Indigenous forage species are being eliminated. Here it is a question of evolving improved systems of management to conserve the botanical composition of the pastures and to maintain their optimal carrying capacity. Areas are now being protected voluntarily throughout the country.

The Japanese wheat collecting expedition in the Near East found that historical sites were frequently excellent for the preservation of wild vegetation of *Aegilops* and other species. Remote areas in Afghanistan are also still fairly protected, although civilization is advancing and will in due course destroy a valuable gene pool. Other Japanese explorers in Nepal, Sikkim, Assam and Bhutan found these countries still relatively unspoilt.

The types of material to be conserved in West Africa include the wild or near relatives of cultivated crops, and the cultivars. The potentialities and requirements of different crops have to be considered in this respect; sorghums, yams, coffee, oil palms and cowpeas can be cited as examples. Conservation of natural vegetation in West Africa would have to take control of bush fires into consideration.

It is obviously not possible to be Utopian in these endeavours, but it is desirable that the urgency of the problem should be brought to the active notice of Governments, and that those responsible for conservation, collection and maintenance of germ plasm should adopt a reasonable sequence of priorities.

2. SUMMARY OF ADMINISTRATIVE PRESENTATIONS AND DISCUSSIONS

Centres for plant exploration

These are justified for a number of reasons (Rudorf, Document PEI/IX/1). Wild species and primitive forms are of great importance in breeding programs. There is an urgent need to preserve the total variability of genera and species within or near the centres of maximum diversity. These centres can do this work and also serve as bases for expeditions, plant collecting being regarded as a long-term activity. Taxonomic work should be linked as closely as possible with ecological observations and studies made of co-evolution of host plants and parasites in the areas of diversity. Collections can be maintained in exploration stations when there is a danger of losing valuable genes if reproduced under different conditions of temperature and photoperiod. Screening of populations is best done under the same conditions as obtained in the centres of diversity. These exploration stations would act as intermediaries on behalf of research stations and individual breeders. The exploration stations could be associated with agricultural development programs in countries situated in regions of maximum diversity, so that valuable genes likely to be eliminated by progress may be conserved.

Possibilities arise for the establishment of national and international exploration stations in the north-west of Argentina for the valuable material available in that region, in Izmir in Turkey for the material available in Turkey itself and in the countries of the eastern Mediterranean and the Near East, and in Peshawar, Pakistan, for the western Himalayan region and Afghanistan.

Some priority should be stated with regard to these alternatives and the following is suggested:

(1) The Mediterranean and Near Eastern centre, including the Caspian and Black Sea zones;

(2) The South American centre proposed by Argentina; and

(3) The Hindukush and contiguous regions.

The matter should be reviewed in a wider context and national Governments should be stimulated through FAO and other agencies to start their own centres. The needs of developing countries in the tropics and subtropics should be borne in mind in deciding on priorities. The network of main centres is far too loose to be efficient. For example, the Argentina centre is only at the margin of the tropical lowlands and the Andean high mountain region; small centres in Bolivia, Peru and Brazil will certainly be necessary. The Rockefeller Foundation is considering setting up a centre in Peru. It would be very difficult to set up centres for the crops of West Africa.

The role of Botanic Gardens and Universities

There does exist an essential interdependence between a qualitative and quantitative knowledge of vegetation, and (1) effective land and forest administration and exploitation, (2) effective exploration for plants of possible economic usefulness, and (3) effective support to floristic studies with their concomitant and allied disciplines, taxonomy, cytotaxonomy, geography, ecology and morphology, and the following remarks are made (Maguire, Document PEI/X/2).

There is today much activity in the study of natural vegetation at local and regional floristic levels, all complementary to the related descriptive disciplines of taxonomy, forestry, geography and ecology. The more comprehensive regional programs can usually be undertaken only by larger institutions, governmental or private. Examples of this kind of extensive operation are: the projected floristic study of continental Australia, to be undertaken by university and governmental botanists; the prodigious descriptive flora of the U.S.S.R.; the preparation of extensive regional floras of Africa in progress at Paris, Kew, the British Museum (Natural History); the extraordinarily competent Flora Malesiana, centred at Leyden and Bogór; the flora of Fiji, at Washington.

In America also extensive and coordinated efforts are under way in the regional study of vegetation, for example: in the United States, the floristic study of the southeastern States and the Caribbean area by Harvard University; the floristic study of the Pacific Northwest and Western Intermontane Region, in cooperation with other institutions, centred at the New York Botanical Garden; studies of the Mexican flora carried on by collaboration of the University of Michigan and the University of Mexico; studies of the central plateau of northern South America (the Guayana Highland), of the central Brazilian plateau, and of the Atlantic drainage of the several Guianas lying between the delta of the Orinoco and the estuary of the Amazon, all centred at the New York Botanical Garden and conducted in collaboration with numerous agencies in Latin America, institutes, botanical gardens and universities; the flora of Colombia, headed by Dr. José Cuatrecasas and centred at Washington and Bogotá; studies pertaining to the biology of the genus *Nicotiana* initiated and led by T.H. Goodspeed, combining extensive field observation and collecting in the Andes, and garden and laboratory activity at Berkeley; the flora of Venezuela involving active cooperative field exploration in Venezuela and herbarium study in Caracas and New York. There are many such others.

These examples serve to show that by long-established procedure, universities (in the broad sense, including colleges and institutes of agriculture), botanical gardens and governmental agencies have practised an essential cooperation and complementary pursuit of this fundamental floristic and geographic inventory of the world plant cover. Collaboration and cooperation of this character could profitably be encouraged especially between the older established institutions where the essential facility of extensive herbaria and library have developed over many

decades, and comparable but young institutions of the newly developing states and regions of the world.

The Agricultural Botany Institute of I.N.T.A. (Instituto Nacional de Tecnología Agropecuaria) at Castelar, Argentina, is a case in point. Research is conducted on taxonomy, physiology, ecology, plant sociology and phytogeography and the utilization of plant resources (Marzocca, Document PEI/X/1). The Institute also has a herbarium and Botanical Garden and can therefore play an important part in studies relating to plant exploration, introduction and exchange.

Institutes studying the flora of different parts of Argentina are:

Instituto Miguel Lillo (Tucumán) - Flora of Tucumán
Museo de Ciencias Naturales (La Plata) - Flora of Buenos Aires; flora of Jujuy
Instituto de Botánica Darwinion (San Isidro, Buenos Aires) - Flora of the Andes/Patagonia Region
Dirección de Parques Nacionales (Buenos Aires) - Flora of the Andes/Patagonia Region
Museo Botánico de la Universidad de Córdoba - Flora of Central Argentina

The Institute at Castelar is working on the Flora of the Arid Zones of Patagonia.

Living collections are maintained at the substations of I.N.T.A., as follows:-

Experimental Stations of:	Collections:
Rama Caída, Mendoza:	Fruit
La Consulta, "	Tomatoes and onions
Luján de Cuyo,"	Plums and grapes
Concordia, Entre Ríos	Citrus
Villa Alberdí, Tucumán	Sugarcane
Pergamino, Buenos Aires	Maize, wheat, barley, rye, oats
Rafaela, Sta. Fe	Groundnuts
P.R. Saenz Pena, Chaco	Cotton
El Sombrerito, Corrientes	Manioc
Balcarce, Buenos Aires	Potatoes
Sumalao, Catamarca	Edible root crops

In addition, various experimental stations maintain collections of forage plants, particularly the Experimental Station of Anguil, La Pampa.

The Jardin botanique de l'Etat in Brussels is now moving to a new site outside the city, and new laboratories of ecology and genetica are to be established. It is considered that botanic gardens should have staff of this type to ensure the correct maintenance of collected

material. There was some disagreement on the potential contribution that botanic gardens could make to the whole program. If botanic gardens may be defined as gardens for the scientific study of plants, and if they are up to the standard of some of the gardens in the tropics, they should be able to contribute greatly to the conservation and study of zone resources. When there is a danger that some of the older introductions are likely to be lost, every effort should be made to conserve them. A committee sponsored by UNESCO is considering the problem of conservation of type specimens in herbaria throughout the tropics. The taxonomic and other studies supported by ORSTOM are also a very important contribution to the botanical aspects of the subject.

International collaboration in collection, distribution and maintenance

International competition is a good thing in many fields of research but it is not so in the case of plant collecting expeditions, where international cooperation is more beneficial. This should be arranged both during the planning and actual conduct of the expeditions, and full use should be made of the results and experiences of previous expeditions. There is, for example, a need for international collaboration in potato collecting expeditions, both during the field work and after the material has been collected (Hawkes, Document PEI/XI/1). A recent potato collecting expedition in Mexico and Central America in 1958 is a good example of international collaboration, since financial support was received from sources in Great Britain, Germany, Holland, Denmark, Sweden and the U.S.A. Living material was distributed to institutes in the contributing countries either at the time of collection or shortly afterwards. Much time would have been saved if smaller samples could have been sent to an Introduction Station for subsequent multiplication and distribution.

FAO has already assisted expeditions by advice from Headquarters, or by assistance rendered by Field Officers, who are always available to assist in matters requiring knowledge of local floras, zones of vegetation, travel facilities and related matters. These types of assistance are, however, on a purely temporary basis.

Over the years, the United States of America has been more active in special explorations. The question of dividing and sharing the proceeds of collections will depend upon the urgency of the problem at home, and the amount of material initially obtained. It is perhaps better for collections to be multiplied under the care of the original collector in his home station for preliminary evaluation before any wider distribution is undertaken.

Again, with special reference to the potato, studies have been made on the wild and cultivated species of potatoes discovered in Peru, Bolivia, and neighbouring countries of South America, beginning with the work of the Soviet expedition first published in 1929 (Hudson, Document PEI/XII/1). Other countries have sent collecting expeditions to South America. These include that made by the British Commonwealth, which led to the assembly and study of the Commonwealth Potato Collection. Some useful

results have emerged from these studies. These include the discovery of lines of Solanum andigenum resistant to eelworm (Heterodera rostochiensis) which have been used by potato breeders in the Netherlands, Germany, Poland and elsewhere. There is a great need for such work to be done collectively on an international basis.

Lack of facilities and financial resources has been responsible for collections of potatoes costing several thousands of pounds dying out or being discarded because of disease. Each country has attempted to maintain its own collection of species and varieties and to send its own collectors to the Americas, both for reasons of national prestige and because there was no central organization to whom this could be entrusted (Hawkes, Document PEI/XII/2). An attempt to solve this problem was made by the British Commonwealth (Commonwealth Potato Collection) and by the United States (Inter-regional Potato Introduction Project). EUCARPIA (European Association for Research on Plant Breeding) feels most strongly that the time is ripe for international cooperation between European countries in this sphere, similar to the inter-state cooperation within the United States of America and that between the various countries of the British Commonwealth. The provision of a European Potato Introduction Station to deal with the admission, quarantine and maintenance of potentially valuable potato stocks is not only advisable but essential, to prevent waste of effort and to reduce considerably the task of maintenance and preservation of important genetic stocks, which has previously rested entirely on the shoulders of breeders from individual countries.

Such a Station would not seek to monopolise all contacts between European breeders and their South American colleagues. On the contrary it would serve as a clearing house for information and a focus for initiative in the use of valuable wild material and primitive forms, which are being used more and more as initial material in all breeding programs. Individual countries would, naturally, be free to organize and finance their own collecting expeditions if they wished, and could be reasonably certain that their material would be maintained and made available to others. Furthermore, the organization of joint or cooperative collecting expeditions by two or more countries would be considerably facilitated if such an Introduction Station was already in existence.

The European Potato Introduction Station would seek to maintain close contacts with the United States Potato Introduction Station (at Sturgeon Bay) and the British Commonwealth Potato Collection, on the one hand, and with Gene-Centre Stations in the Andes and Mexico when these come into existence, on the other.

Whilst, on a short-term view, the European Potato Introduction Station could content itself with purely routine matters, it is felt strongly by the President and Board of EUCARPIA that the best interests of potato breeders would be served if a program of basic research were also initiated. Breeders need information on cytotaxonomy, interspecific fertility, mode of inheritance of certain genes, and techniques for the

storage of tubers, seeds and pollen, so as to be able to make the best use of the material which the Introduction Station would supply.

The New Crops Research Branch, Crops Research Division, Agricultural Research Service at Beltsville, Maryland, is an outstanding example of the organization established to meet the many and diverse needs of plant exploration and more particularly plant introduction. The major responsibility of this unit is to secure for cooperating federal, state and private research workers those plant stocks needed for the achievement of their objectives (Hyland, Document PEI/XIII/1). These may cover agronomic, horticultural, genetic, chemurgic, pathological and other problems. Plant materials may be obtained through international exchange, purchase or by foreign and domestic exploration. To carry out this responsibility successfully, proper attention and careful consideration to the following procedures are required:

(1) Collation of requests from research workers and setting up explorations or procurement priorities based on urgency, scope or problems, areas to be covered and available funds.

(2) Procurement of plant stocks from centres of origin, foreign plant breeders, or other sources as dictated by bibliographical and geographical reviews.

(3) Processing introductions through sanitary inspection.

(4) Plant quarantine.

(5) Taxonomic identification of introduced stocks.

(6) Preparation of inventories.

(7) Distribution, multiplication and evaluation.

(8) Preservation of germ plasm.

The New Crops Research Branch administers four Federal and four State-Federal Plant Introduction Stations. The headquarters and dates of establishment are as follows:

Federal Plant Introduction Stations	State-Federal Plant Introduction Stations
Miami, Florida (1898)	Ames, Iowa (1947)
Chico, California (1904)	Geneva, New York (1948)
Glenn Dale, Maryland (1919)	Experiment, Georgia (1949)
Savannah, Georgia (1919)	Pullman, Washington (1952)

The distinction between the two groups lies largely in their dates of establishment and original objectives. Whether an introduction is ordered to one of the Federal or to a State-Federal Station depends upon the nature and type of plant. Generally, the Federal Stations receive introductions of woody species which cannot be treated as annual

crops, certain ornamentals, fruits subject to quarantine or disease indexing programs, and little known plants to be studied for their potential as "new crops". Research is undertaken on methods of propagation, media for germination of seed, effects of shipping and packing techniques on living plant material, cultural and evaluation studies related to crops such as bamboo, pistachio nut, and certain ornamentals. These stations have also been used as holding centres for introduced fruit breeding stocks.

The business of maintaining introduced germ plasm is expensive and time-consuming. However, in view of the efforts and costs of the original collection and, more important, the gradual disappearance of indigenous species in many parts of the world, this maintenance should be justified. Small storage units are in operation at the State-Federal Plant Introduction Stations in the U.S. for holding what is termed "working stocks". Once the initial demand from research workers has been satisfied, such stocks are then eligible for storage in the National Seed Storage Laboratory in Ft. Collins, Colorado. This facility was dedicated in 1958 and is now in full-scale operation. It is not the present policy of this Laboratory to accept seeds for storage from other countries.

The pattern of needs of germ plasm has changed during the 60-year period; more emphasis is now being placed on the development of new crops and the chemical screening of numerous plant families to determine their potential use for oils, proteins, fibres, etc. The future assembly of more stocks through exploration and introduction to satisfy these new demands may ultimately lead to economically important new crops. The same situation can develop in other programs of agricultural improvement throughout the world, which means increased handling or exchange of plant materials on an international basis. As specialization in agricultural research develops, an increased value is placed on the individual worker's time and effort. In this respect, a well-coordinated, informative and productive plant introduction program can increase the worker's efficiency in developing new crops or improving the older useful varieties.

The South Pacific Commission is an advisory and consultative body set up in 1947 by the six governments responsible for the administration of island territories in the South Pacific region. These governments are: Australia, France, the Netherlands, New Zealand, the United Kingdom and the United States of America. The Commission's purpose is to advise and assist the participating governments in ways of improving the well-being of the people of the Pacific Island territories. It is concerned with health and economic and social matters.

Plant introduction was among the first activities of the South Pacific Commission. Its program was initiated in 1949 and has developed into a regional plant exploration and introduction service (Barrau, Document PEI/XIII/2). The importance of this service is reflected

in the following examples of its activities:

Since 1957 about 500 species and varieties of economic plants have been introduced into the various South Pacific territories through this service;

A systematic survey has been undertaken of the coconut palm population of the tropical Pacific islands to find material suitable for improvement through breeding and selection;

The breadfruit trees of Melanesia, Micronesia and Polynesia have also been surveyed.

This service is one of the few organizations in the field of plant exploration and introduction working on the basis of international co-operation, and one of the first inter-governmental consultations on plant introduction was convened by the South Pacific Commission in 1955 at Canberra, Australia, under the chairmanship of Mr. W. Hartley, Division of Plant Industry, C.S.I.R.O., Canberra. It is of interest to all workers in this field to review the history, past experiences and achievements, working methods, present organization and program of this Service.

The Plant Introduction Section of the C.S.I.R.O. Division of Plant Industry is responsible for the introduction and preliminary testing of new plants of potential economic value, particular attention being given to pasture and forage plants because of their importance in the Australian economy (Hartley and Neal-Smith, Document PEI/XIII/3). Introductions include both recognized cultivars and wild ecotypes, these being obtained on an exchange basis with institutions in all parts of the world, supplemented by overseas plant exploration in regions of special interest. The Section has delegated responsibility for the quarantine checking of all introduced plant material. New introductions are tested at nursery quarantine centres maintained in some of the main climatic zones of the continent, and the more promising varieties are included in regional trials, most of which are organized on a co-operative basis. Close liaison is maintained with plant breeders and others interested in the use of introduced plants to meet special requirements. Research activities include phytogeographical studies designed to provide a better basis for environmental comparison and studies on the technique of pasture plant evaluation. Growth studies under controlled environments will be developed to supplement field testing.

Plant introduction of various economic species to replace local fruits and vegetables, ornamentals for aesthetic value, and better fodders for the development of animal husbandry is the responsibility of the Botanical Section, Plant Industry Division, of the Department of Agriculture in Thailand (Yongboonkird, Document PEI/XIII/4). To maintain the collection for public distribution, experimental stations have been set up in different parts of the country to serve as agricultural banks, as well as breeding and propagation centres for economic crops. The present objective is to encourage farmers and agriculturists to develop and grow food crops with the aid of genetical techniques.

The exploration of timber trees and forest products of economic importance had been done by the Royal Forest Department of Thailand since the foundation of the Department in 1907, when herbarium specimens of doubtful or unknown timber species had been sent to the then Royal Botanic Gardens, Calcutta, for identification (Smitinand, Document PEI/XIII/5). After the reorganization of forest administration in 1935, the Forest Products Research Division and the Silvicultural Division came into being; both divisions work together on plant exploration and introduction. The Section of Forest Botany and Zoology, Forest Products Research Division, carries on the botanical survey of the country, whereas the Division of Silviculture deals with the introduction of plants. Forest Experimental Stations established in different parts of the country ensure the propagation of species introduced for trial. The exchange of seeds and living collections has been initiated with neighbouring countries and elsewhere through the medium of FAO.

A Plant Introduction Service was started in Pakistan in July 1958 with the following aims and objects (Hafiz, Document PEI/XIII/7):

(1) To obtain seeds or seedlings of new and useful crop plants from foreign countries as well as from one wing to another and study their performance and behaviour under local conditions.

(2) To obtain from abroad plant material of outstanding varieties of crops already being grown in Pakistan, with a view to acclimatizing them for suitable regions of this country.

(3) To conduct trials on the cultivation and sowing dates, and the manurial and irrigation requirements of new crop plants and other material obtained from abroad.

(4) To supply seeds and seedlings of crop plants needed by Provinces and other Departments for their research.

(5) To serve as a clearing house for supplying information on various plant introduction activities.

The Plant Introduction Service consists of:

i) A Central Agency-cum-clearing house with the Food and Agriculture Council, Pakistan.

ii) One Plant Introduction Section in East Pakistan.

iii) One Plant Introduction Section in West Pakistan.

An area of 261 acres is being acquired in Ghulam Mohammad Barrage in District Thatta, West Pakistan, for the establishment of a plant introduction garden including a botanical garden, arboretum, herbarium, seed multiplication area, etc. It is contemplated that a collection of fodder

trees, shrubs and bushes, grasses, legumes, etc. suitable for arid and semi-arid zones will be maintained here. In addition, the Provincial Plant Introduction Sections have also acquired areas for establishing regional centres at Dacca, Peshawar, Rawalpindi and Lyallpur, with glasshouses and other equipment.

In Latin America several lines of approach will have to be adopted in order to make full use of plant introduction in its various forms (León, Document PEI/XIII/6). For instance:

(1) Setting up plant introduction services, concerned also with quarantine and experimental testing, on an international scale, or improving the existing services.

(2) Intensifying regional services, whether concentrating on a specific crop or non-specialized, among different countries in the continent and elsewhere.

(3) Making known on a wider scale the plants in private or commercial collections in the Americas by means of proper cataloguing and exchange of plant materials and the establishment of freely accessible collections.

(4) Establishing an international intelligence service for diseases and pests to assist in preventing their entry into countries, and to facilitate quarantine officials in ensuring that only healthy plant material is introduced.

(5) Promoting exploration for, and the introduction of economic crops in four ways:

    (i) Introduction of "wild stock" to increase existing variability.

    (ii) Introduction of plant material of American origin, but already subjected to selection in countries outside the continent.

    (iii) Introduction of new crops, that is, plants entirely unknown or rarely found in the Americas.

    (iv) Conservation of the American germ plasm, particularly of plants not yet subjected to genetic improvement. This will entail search for and conservation of indigenous plant material from the two centres of diversity reported in America. An equally important task is the conservation of genes which can be utilized for advanced programs of improvement for crops which, like maize, potatoes, tomatoes and others, have undergone intensive genetic improvement work in the Americas and elsewhere in the world.

A Plant Introduction Service was established in Israel in 1957, in the Agricultural Research Station at Rehovot, now the National and University Institute of Agriculture. This service is largely a miniature reproduction of those in U.S.A. and Australia. The policy of introduction is dependent upon the needs of research workers and the general trend of agricultural development. The maintenance and utilization of material are the most difficult tasks. Techniques of nursery testing should be developed in close co-operation with specialists in the particular crops.

In the discussion on plant exploration and introduction services the need for increased attention to grain legumes for direct human consumption was stressed, with particular reference to the Far East and Tropical Africa. There is also a need for greater interchange of fruit trees in tropical countries, mango varieties from India being mentioned as an example.

The history of plant introduction provides many examples of unexpected difficulties or failure on account of insufficient attention being paid to pests and diseases, and this strongly emphasizes the importance of continuous co-operation between the specialists of plant introduction and plant quarantine (Granhall, Document PEI/XIV/1).

It is often extremely difficult to foresee the consequences of introduction of a pest or disease or even to know when an introduction of this sort has in fact occurred. The potato plant in Europe is, for instance, today badly attacked by Late Blight, Wart Disease, Root Eelworm, virus diseases, and so on, but little is known of how and when these attacks really started. It is quite possible that the parasites were already present on the potato in its native South America and were brought to Europe together with the first tubers. Documents from Peru dated 1571 described a disease which might well be Late Blight. The first time this disease was observed in Europe was, however, around 1845-47, when Ireland and several other countries were severely shocked by the devastation it caused. The sudden appearance and spread called for drastic and even supernatural explanations, but the real reasons are still unexplored.

A pest or a disease might be quite harmless in one country and therefore overlooked, but following its host plant to another corner of the world might find more favourable climatic conditions, an absence of natural enemies, or it might perhaps discover other more suitable host plants, making it an extremely dangerous intruder. New biological races of the pest can also often reduce the possibilities of control. Sometimes a pest can use a plant species other than its principal host as a carrier or as a mere mechanical means of conveyance - rust fungi usually have intermediate hosts, virus diseases have insect vectors which can move to other plants; potato nematodes have been intercepted on _Convallaria_ roots at quarantine inspections. Special difficulties are causedby virus diseases, as they are often

extremely difficult to detect by external symptoms. The situation is no easier if the virus is polyphagous, as, for example, the Aster Yellows Disease which has about 300 host plant species belonging to 48 plant families.

From the point of view of plant quarantine the greatest hazards of transmission of pests and diseases are connected with consignments (large or small) of propagating material (seed, tubers, corms, bulbs, budwood, cuttings, living nursery plants). Most countries have in consequence drawn up special lists of host plants, the entry of which is forbidden. The value of a plant introduction also very much depends on the soundness of the material and its freedom from dangerous pests and diseases. To obtain the best possible guarantee, it is necessary to establish and maintain close contact with the plant quarantine service. A phytosanitary certificate from the plant protection service of the exporting country, careful inspection and perhaps disinfestation or disinfection by the plant protection service of the importing country, and in cases of possible virus infection growing under supervision at an isolated quarantine station for a sufficient length of time, are all prerequisites for the provision of such a guarantee. Subsequent observation of attack should immediately be communicated to the plant protection service.

Plant quarantine is very important in the distribution of cacao breeding material (Tinsley, Document PEI/XIV/2). Although high-yielding Amazon hybrids have been developed for use in Africa, with some tolerance of virus infection and resistance to infection with Blackpod disease (Phytophthora palmivora), it is nevertheless true that varietal improvement compares unfavourably with progress made in other tropical crops. Inaccessibility of material together with the restrictions imposed by inadequate quarantine facilities are probably the most important factors.

Any answer to this problem is bound to be expensive and difficult to organize. The Eighth Inter-American Cacao Conference stated: "There is an urgent need for a properly equipped, staffed and supported International Cacao Quarantine Station where virus indexing and other diseases or pest quarantine problems can be safely handled, and for safe assemblage, quarantine and distribution of useful germ plasm including the output from new plant collecting efforts". The idea of a central International Cacao Quarantine Station merits serious consideration. Assuming that funds were available for adequate staff and equipment to be provided, then there is no reason why the bulk of cacao material should not pass through this station. Ideally, the sequence of quarantine control should be:

(1) Quarantine and inspection in the donor country.

(2) Further inspections and tests at the International Station.

(3) Additional quarantine by the receptor country either directly or by other agencies in temperate countries. This procedure is usually followed in Africa by diversion through Europe.

In the discussion on quarantine questions, emphasis was placed on the dangers associated with the introduction of pests and diseases along with plant material from expeditions or other sources, and also with the introduction of spores and other dangerous pathogens by specialists studying their behaviour and biology.

3. STAGES IN ACTIONS RELATING TO PLANT EXPLORATION AND INTRODUCTION

It should be understood that this section is merely a statement of an ideal sequence of actions and organizations, that much of the work covered in the following paragraphs is already in progress at many centres throughout the world and merely requires to be co-ordinated, but that a long-term plan of a more comprehensive nature would be expected to develop on the lines indicated in this document. Reference should be made to the opening paragraph in the recommendations which brings to the urgent notice of all Member Governments the great need to support existing activities and organizations and also to take all possible action to conserve the world's gene resources, whether in the form of wild species, primitive forms and agro-ecotypes or cultivars.

From the discussions under all items of the Agenda of this Meeting, it appeared that there is an overall structure or sequence of requirements and actions which should be set down as a basis for planning for the future. This represents the ideal structure of an important subject of pure and applied science in relation to crop improvement in general. Although plant introduction is as old as history, if not older, and although it has been carried on in a relatively haphazard way for thousands of years, it is only within the last 50 to 100 years that scientific principles and techniques have been applied to its development. We now have a good knowledge of the major centres of crop diversity, and of the wild relatives of the cultivated varieties, although much still needs to be done, particularly with regard to tropical crops.

It has to be appreciated that the subject of plant exploration and introduction should embrace action with regard to all levels of crop improvement, from the wild species in the natural vegetation to the highly bred cultivars, something as follows:

Wild species: These are more important in some groups of crops than in others. The main action required is their preservation in their natural (but appropriately managed) plant communities. The urgency of the need for this conservation varies from one centre of diversity to another, according to past and present pressure of human and livestock population.

Primitive cultivated forms and land races (agro-ecotypes): Agricultural development and general progress will progressively eliminate these in favour of "improved" more uniform varieties. These land races are of great value for future breeding work, with reference to increased disease resistance, etc. There are many different ways of preserving these - either *in situ*, or in living collections

maintained in similar climates or (depending on the crop) in special research stations, not necessarily in closely similar climates.

Cultivars improved by selection, hybridization or other breeding methods: No great problem arises as these are mostly maintained in research stations. Old discarded cultivars should, however, be preserved. Lists of cultivars should be made available as a basis for exchange.

Organization

The conservation of our plant resources demands a specific organization comprising stations of plant exploration, stations of plant introduction, the maintenance of living collections, the development of research and training, and obviously the co-ordination of the whole.

A special effort should be made from now on to ensure that existing research stations include in their programmes of work, where a particular urgency arises, the maintenance of plant material of one or several species. They may thus to some extent from this moment play the role of stations of exploration or introduction on a national or regional basis.

Plant Exploration Stations

These would be located in or reasonably near to the centres of maximum diversity. They would be national or international stations. Their scientific staffs with thorough knowledge of local conditions would make expeditions in the region on behalf of enquirers or in company with specialist expeditions. The work of the stations would be linked to and would largely depend upon a network of areas of conserved and appropriately managed natural vegetation, and the availability within the region of adequate resources of primitive cultivated forms for collection, study and initial multiplication. These stations would be available for use by people in the region and by visitors from elsewhere. Facilities would be available for the taxonomic and other study of the material, and the investigations of co-evolution of parasites with crop plants. Initial multiplication of lots too small for distribution would be done. There would be a good library of publications on the vegetation and flora of the region, maps and other information.

Plant Introduction Stations

These would be established in receiving countries, either on a regional basis where expedient or a national basis, and would be responsible for groups of plants or individual crop plants. They would be responsible for the receipt, study and maintenance (and application of quarantine standards) of material from the plant exploration stations,

independent expeditions, local collections of wild species, primitive forms and agro-ecotypes, and interchange of cultivars. They might also be responsible for maintenance of discarded but still potentially useful breeders' lines. There may be cases where a special type of plant introduction station may be visualized, again responsible for assembly, maintenance, study and quarantine on a national or regional basis, but dealing with specific crops or groups of crops. The proposed European Potato Introduction Station would come in this class, and similar action might be visualized for horticulture, forestry and other groups of plants.

Maintenance of Living Collections

This would be the responsibility not only of the Plant Introduction Stations, but also of Research Institutes, Botanic Gardens, Research Foundations and similar centres. Assembling and publication of lists of collections and their custodians would be necessary.

Research and Education

Now that the subject of plant exploration and introduction is developing into an important and relatively distinct aspect of general crop improvement, it is desirable to consider the future of research and education in this field.

This would involve the establishment of a Research Department in a University, and also the provision of practical training at Plant Introduction Stations or similar centres.

Coordination

To coordinate and promote all these diverse actions, there is a need for an international Agency to give special attention to activities in plant exploration and introduction. It should have at least three experts who should be responsible for coordination and development with all important food, horticultural, fodder and industrial crops, in both temperate and tropical latitudes.

The Agency should draw the attention of Governments within the centres of diversity to the need to preserve and utilize these valuable resources correctly, particularly where agricultural development and technical advances constitute a serious menace of permanent loss. In greater detail this Agency should deal with the following matters:

(1) It should promote national and international cooperation with reference to all activities connected with centres of maximum diversity, by drawing the attention of research organizations to the many research problems which arise and to promote their cooperation.

(2) The Agency should gather information on the existing living collections of different genera and species, their maintenance and the availability of stocks with valuable genes for use in breeding programmes.

(3) The Agency should promote meetings of experts concerned with the different centres of diversity where discussions would be held on the inherent problems and the objectives of exploration.

(4) The Agency should stimulate and, if necessary, advise and coordinate the work of experts and specialized bodies by suggesting to governments concerned that they set up national introduction centres.

(5) The Agency should also study the possibility of setting up international exploration stations in regions of maximum diversity. These international centres could develop as models for the smaller national introduction centres.

(6) The Agency should coordinate quarantine facilities on a long-term basis to permit the fullest use of the material preserved and offered by national or international exploration and introduction stations.

RECOMMENDATIONS

1. Recognizing the great importance to this and future generations of preserving the pool of genetic variability which now occurs in the major "gene centres" of the world, but which is now threatened with destruction either through over-grazing and related malpractices or through the replacement of "land races" by improved varieties, the Meeting recommends that FAO, through its Member Countries, promote the establishment of international and national exploration stations in or near such gene centres, to assist in the exploration of the regions concerned, in the establishment and maintenance of suitable conservation areas, and in the preliminary multiplication and investigation of the plant material collected.

2. The establishment of exploration stations should normally be preceded by an investigation and evaluation of all available information about the centres of genetic diversity for each of the more important crops, leading to an assessment of relative priorities. The Meeting recommends that FAO seek the assistance of selected specialists in each of the crops concerned in undertaking such an investigation.

3. In this connection, the Meeting noted with interest the proposals made for the establishment of exploration stations in Turkey, in north-western Argentina, and in northern Pakistan. The Meeting strongly endorses these proposals and recommends that interested Governments should request FAO, other organizations or other interested countries to give technical and other aid to assist in the establishment and maintenance of the stations and any other effort of this kind.

4. The Meeting recognized the great value of international collaboration in the planning and execution of plant collecting expeditions, and recommends that (a) Governments and international and other agencies planning such expeditions should inform FAO in good time, and (b) FAO continue and expand its activities in serving as a clearing-house for information about current and projected expeditions, and continue to assist the expeditions by making available the services of its field officers as far as practicable.

5. Recognizing that plant material obtained through exploration stations will require careful phytosanitary examination and that introductions of plant material will require lengthy study within the regions in which they will be used, the Meeting recommends that FAO provide the necessary advice and assistance to Member Countries for the establishment of National Introduction Stations, where these do not already exist, to supplement those which already exist in some countries. It further recommends that groups of countries with similar crops, problems and environment receive encouragement and technical aid for the establishment of regional introduction stations and in that respect special attention should be given to the tropical part of Africa.

6. The Meeting noted with interest the suggestion made by EUCARPIA for the establishment of a European Potato Introduction Station. It recognized that crop stations of this kind may be of value where the crop concerned is an important one involving special quarantine and maintenance problems, and recommends that FAO request interested countries to support the proposal.

7. To assist in a full evaluation of the problems likely to be involved in the establishment and maintenance of Exploration and/or Introduction Stations, the Meeting recommends that FAO carry out a survey of action currently undertaken or proposed regarding the establishment of such stations, and of existing institutions which might undertake some or all of the functions of the proposed Exploration and/or Introduction Stations.

8. Recognizing that knowledge of the local and regional flora forms an indispensable basis for the work of collecting expeditions, and that local botanists may frequently be in the best position to collect plants within their region, the Meeting recommends that FAO take steps to interest Member Countries and appropriate organizations in the collection and collation of information on local and regional floras in preparation, and in the work of local taxonomic botanists and in the publication of their results.

9. Recognizing that in many countries botanic gardens have played an important role in the maintenance and exchange of plant material, the Meeting recommends that FAO support the survey of those botanic gardens and arboreta which maintain collections of introduced material or specialized collections of cultivars, and take action to promote the establishment of new or the development of existing gardens, particularly in tropical and subtropical regions.

10. The Meeting recognized the very important aspect of plant introduction involved in the exchange of established cultivars and the setting up of living collections, and the special significance of this for some tropical and other countries which are at present unable to sustain intensive breeding programmes. FAO has assisted greatly in this exchange, both directly and through the compilation of lists and catalogues of species and cultivars available in various countries and institutions. The Meeting recommends that this work be continued and expanded, paying special attention to food crops and to tropical and subtropical regions. Among the cultivated plants of these tropical and subtropical regions and for the above recommended work, an order of priority should be established; for instance, special attention should be paid to the coconut palm, this plant having been the object of similar recommendations at the 8th and 9th FAO Conferences.

11. The value of lists of species and cultivars available at different institutions is enhanced if information is readily available about the climatic and other environmental factors of the institutions concerned. The Meeting recommends that an endeavour be made to incorporate such information in future lists prepared by FAO or other Agencies.

12. The Meeting recognized that comparative ecological and floristic studies are important in helping to provide a sound basis for plant introduction and for an understanding of the processes involved in the adaptation of plants to a new environment. It therefore recommends that FAO, directly and through its Member Countries, should encourage such studies.

13. There are at present no institutions where training can be provided in the administrative and practical aspects and techniques of plant exploration and introduction. The Meeting therefore recommends that FAO and Member Countries arrange for practical training in this field, supported wherever possible by some kind of certificate or diploma.

14. The Meeting appreciated the inadequacy of fundamental research on the origin, genecology, adaptability, variability and distribution of plants of economic importance, which is hindering the development of practical work in the study of utilization of the world's gene resources. The meeting therefore recommends that FAO, through Member Governments, approach universities and research institutes with regard to the development of such research and, where appropriate, the establishment of a research department in this field.

15. The Meeting recognized the importance of effective plant quarantine measures as applied to the field of plant exploration and introduction, especially in the international exchange of plant stocks for experimental purposes. It therefore recommends that FAO and Member Countries provide technical and other assistance insofar as existing facilities permit, even to the extent of setting up regional quarantine stations. Such stations should, as far as practicable, be closely linked to the Introduction Stations.

16. The Meeting recognized that only a small part of the program of activities outlined in this report and recommendations can be undertaken by the present staff of the Division of Plant Production and Protection of FAO. It is nevertheless an urgent and important program, the furtherance of which lies within the proper scope of FAO. The Meeting therefore strongly recommends that the Director-General of FAO take action to strengthen the Plant Production and Protection Division of FAO by the appointment of at least three or four scientists of suitable training and experience, and charged with responsibility, under the Director of the Division, for the development of the program as outlined. The Meeting further recommends that the Director-General of FAO constitute an Expert Panel to assist and advise the Director of the Plant Production and Protection Division in this field.

DOCUMENTS OF THE MEETING

General

PEI/G/1 ANGLADETTE, A. Note technique générale.
PEI/G/2 KOECHLIN, J. Activités de l'Office de la Recherche Scientifique et Technique Outre Mer (O.R.S.T.O.M.)

Item 5 - FAO Action to date and Conference resolutions

PEI/V/1 WHYTE, R.O. The work of FAO in support of plant exploration and introduction 1947-61.

Item 6 - Current actions and future requirements with regard to specific major and minor crops

General

PEI/VI/1 SAUGER, L. Les introductions de plantes dans la République du Sénégal.

(a) Cereals

PEI/VIa/1 YAMASHITA, K. A preliminary report of the Botanical Mission of the University of Kyoto (B.M.U.K.) to the Eastern Mediterranean Countries, April - July, 1959.
* PEI/VIa/2 RACHIE, K.O. Sorghum improvement in India.

(b) Industrial Crops

PEI/VIb/1 STEIN, H. Some evolutionary trends in *Ricinus communis*

PEI/VIb/2 KRUG, C.A. Need for expanded exploration and introduction activities to promote further genetic improvement of coffee, cacao and rubber
PEI/VIb/3 WYCHERLEY, P.R. and BROOKSON, C.W. International traffic in *Hevea* planting material

(c) Grain legumes

* PEI/VIc/1 STANTON, W.R. A note on work in progress in Northern Nigeria with special reference to grain legumes.

(d) Tropical perennial crops

PEI/VId/1 BARTLEY, B.G.D. Exploration for *Theobroma* in the Amazon Valley
* PEI/VId/2 PORTERES, R. Prospection agro-écologique des caféiers sauvages et cultivés

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* Paper prepared for meeting but, due to late arrival, not presented. Will be included in proceedings when published.

(e) Horticulture, fruit and potatoes

PEI/VIe/1 BANGA, O. Origin and distribution of the Western cultivated carrot.
PEI/VIe/2 BOOM, B.K. Plant introduction for ornamental purposes.
PEI/VIe/3 (Paper withdrawn)
PEI/VIe/4 SOUTY, J. Travail en cours à la Station de Recherches d'Arboriculture fruitière de la Grande Ferrade, Pont de la Maye (Gironde), France.
PEI/VIe/5 PANSIOT, F.P. Lists of living collections of fruit species.

(f) Herbage and fodder

PEI/VIf/1 THOMAS, P.T. The assessment and utilization of climatic ecotypes in the breeding of herbage grasses.
PEI/VIf/2 ELLERSTROM, S. Some results from a preliminary test in Sweden of plant material collected in the Mediterranean Region.
PEI/VIf/3 OPPENHEIMER, H.R. Some wild clovers of Israel of agricultural interest.
PEI/VIf/4 HARTLEY, W. The application of comparative floristic studies to the problem of pasture plant introduction for arid Australia.

Item 7 - The genecological basis of exploration and collection

PEI/VII/1 HARTLEY, W. Phytogeographical basis of pasture plant introduction.
PEI/VII/2 JUCCI, C. The genecological basis of exploration and collection.
PEI/VII/3 OPPENHEIMER, H.R. Ecological relationships of wild emmer in Israel and A. Aaronsohn's contribution to the theory of origin of cultivated wheat.
PEI/VII/4 PURSEGLOVE, J.W. Some problems of the origin and distribution of tropical crops.
PEI/VII/5 HEDIN, A. Observations sur l'origine, la classification et l'écologie des espèces fourragères.
PEI/VII/6 ROSS, H. The importance of the potato gene centre for breeding and understanding of the origin of the cultivated potato.
PEI/VII/7 PERRIN DE BRICHAMBAUT, G. Contribution de la climatologie à la prospection et à l'introduction de matériel végétal.

Item 8 - The conservation of natural vegetation (for wild species) and primitive cultivated forms in regions of greatest diversity

PEI/VIII/1 BRIEGER, F.G. Collections and evaluation of indigenous races of maize.
PEI/VIII/2 MINISTRY OF AGRICULTURE AND FORESTS, Italy. Rapport sur le Point 8 de l'ordre du jour, présenté par la Direction générale de l'économie des pays de montagne et des forêts.

Item 9 - The establishment of centres for exploration and preliminary introduction in regions of greatest diversity

PEI/IX/1 RUDORF, W. Exploration centres within the areas of gene centres, and introduction centres in remote countries with large areas of cultivated plants.

Item 10 - Botanical studies on natural flora in the field and at Botanic Gardens and Universities, taxonomic and cytological investigations and the maintenance of herbarium collections

PEI/X/1 MARZOCCA, A. Las investigaciones botánicas en el Instituto Nacional de Tecnología Agropecuaria de la Argentina.
PEI/X/2 MAGUIRE, B. Notes for informal comment on Item 10 of Agenda.

Item 11 - International collaboration in collecting expeditions

PEI/XI/1 HAWKES, J.G. The need for international collaboration in potato collecting expeditions.

Item 12 - International collaboration in the distribution of the proceeds of collections and in their maintenance, study and utilization

PEI/XII/1 HUDSON, P.S. International cooperation in collecting South American species of potato.
PEI/XII/2 HAWKES, J.G. The EUCARPIA European Potato Introduction Station.
PEI/XII/3 EUCARPIA. Summary of replies to questionnaire.

Item 13 - Present organization and status of plant introduction services

PEI/XIII/1 HYLAND, H.L. Plant introduction objectives and procedures in the United States.
PEI/XIII/2 BARRAU, J. The Plant Exploration and Introduction Service of the South Pacific Commission.
PEI/XIII/3 HARTLEY, W. and NEAL-SMITH, C. Plant introduction and exploration in Australia.
PEI/XIII/4 YONGBOONKIRD, Miss U. The activity of the Department of Agriculture in plant introduction.
PEI/XIII/5 SMITINAND, T. The role of the Royal Forest Department in plant exploration and introduction.
PEI/XIII/6 LEON, Jorge A. La importancia de la introducción de plantas en América Latina.
PEI/XIII/7 HAFIZ, A. A brief note on plant introduction work in Pakistan.

Item 14 - Quarantine services in relation to plant introduction

PEI/XIV/1 GRANHALL, I. Plant introduction and plant quarantine.
PEI/XIV/2 TINSLEY, T.W. Plant quarantine and the distribution of cacao breeding material.